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Johnny-on-the-Spot

By R. T. Strohm.

DIRT and grease have not been sparing
On the overalls he's wearing,
And he doesn't have the bearing
Of Apollo Belvedere.
To avoid a social blunder,
He and swelldom dwell asunder,
But he surely is a wonder
As a running engineer.

He is free from affectation,
False conceit or pride of station,
For his fund of information
Came with knocks and jolts and hooks;
But, to satisfy his yearning
For a deeper, better learning,
Leisure hours find him turning
To his engineering books.

If a crankpin bearing seizes, or a blower gets the wheezes,
Or some other such diseases of the plant come unawares,
With his lubricating can or slight adjustment with a spanner,
In a rapid, knowing manner he proceeds to make repairs.

If a driving belt has parted and the shift feels heavy-hearted,
He's the chap to get things started with the minimum delay;
And because he's always ready, quick and capable and steady,
Trained to use both hands and head, he draws a maximum of pay.

Traveling Screens at Northwest

By Thomas Wilson

SYNOPSIS—An installation of seven screens, each designed to serve 15,000 kw. in generating capacity. A feature of the new screens is the pivoting of each unit so that it may be turned to a horizontal position instead of being hoisted vertically out of the water for repairs.

Many *Power* readers will probably remember the initial plans for the Northwest Station of the Commonwealth Edison Co., of Chicago, as described in our issue of Apr. 29, 1913. The station was originally laid out to contain six 20,000-kw. turbo-generators arranged on the unit plan—a total of 120,000 kw. These plans in a general way are being followed except that units of much greater capacity are being installed. The building is now complete. It contains the two 20,000-kw. vertical machines first installed and a third unit of horizontal type, which was put into operation last September and has been developing 35,000 kw. These three are all of the 25-cycle type rated on a unity power factor basis. A fourth unit, 35,000 kv.-a. 60 cycles, is now under construction and two additional units will complete the station and give an aggregate capacity of 180,000 kw.

To shut down or in any way interfere with the efficient operation of a plant of such magnitude or even with one of the mammoth units would be a matter so serious that it has necessitated special precautions guarding all vulnerable points. In this connection nothing is more important than clean water for circulation through the condensers and for boiler makeup purposes.

Previous to the building of this station, it had been common practice to use gratings and screens of varied design and arrangement to separate foreign matter from the original supply. It was not uncommon to place a number of screens in series in the intake. The difficulty with these sliding screens was the great amount of labor required at the cleaning periods, which were more or less frequent, depending upon the character of the water and the volume of flow, and the fact that at this time more or less sediment was sure to get by and find its way through the pumps to the condenser tubes. As each screen was raised, more or less sediment would drop off and pass on to the next screen, and eventually some of this undesirable material would get into the intake.

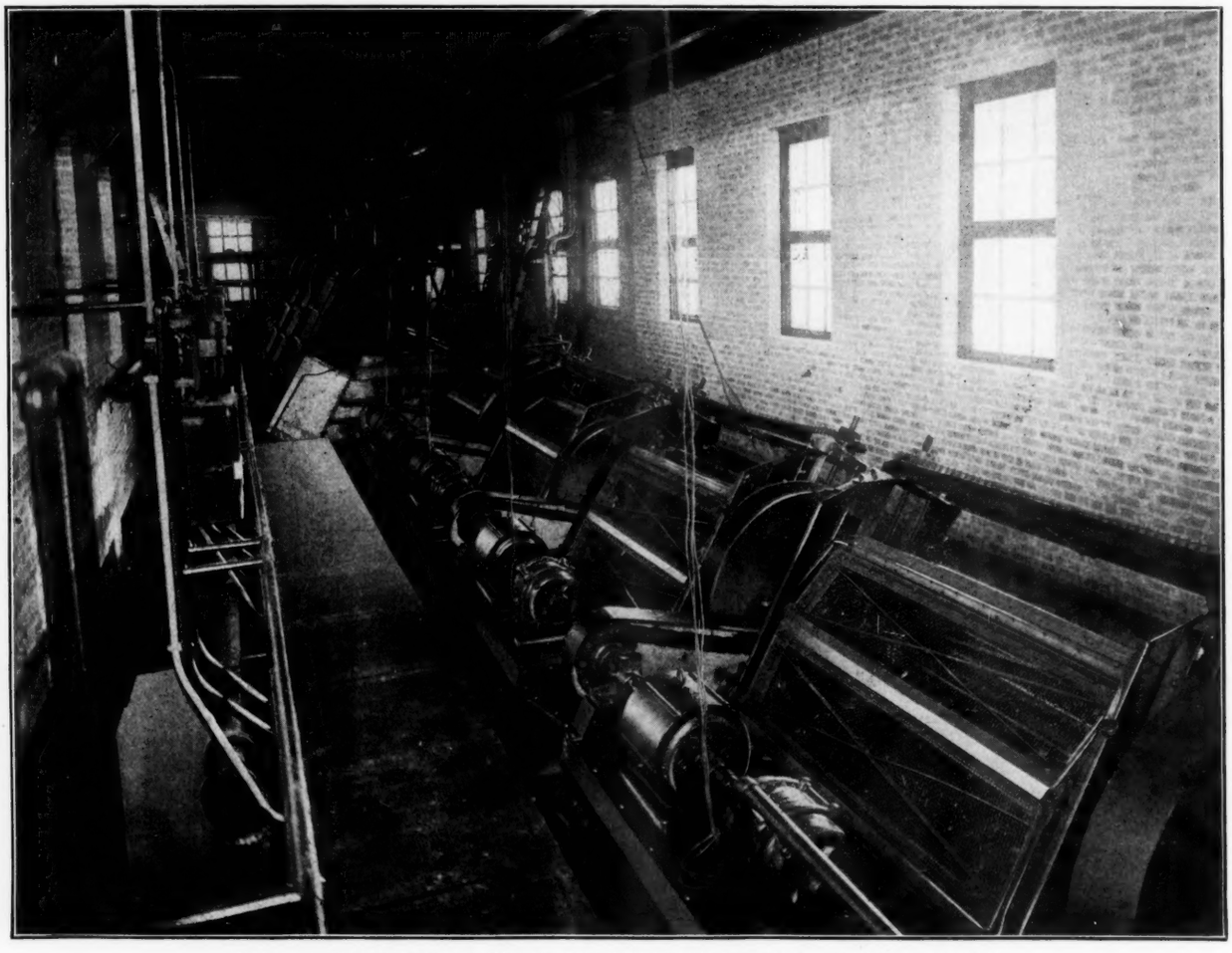


FIG. 1. TRAVELING SCREEN INSTALLATION AT NORTHWEST STATION

When the Northwest Station is fully equipped, it will have a circulating-pump capacity of more than 300,000

gal. per min. This enormous quantity of water will flow to the plant through a tunnel 10 ft. square. The source is the north branch of the Chicago River, a stream having a well-earned reputation for filthy water.

To obviate the usual difficulties and to insure a supply of circulating water that would contain the minimum amount of foreign matter, Sargent & Lundy, consulting engineers for the Commonwealth Edison Co., first evolved the idea of a traveling screen that would be automatically cleaned while in operation and never need to be removed from the water except for repair. After their design three screens were built by the Chain Belt Co., of Milwaukee, and installed in 1910 at the Northwest Station to serve the two 20,000-kw. units. A number of other plants followed suit, adopting this type of screen, and last year four more, made by the same company that put in the initial installation, were installed at the Northwest Station, two serving the third unit started up in September, while the other two are intended for the machine now under construction. The seven screens appear in Fig. 1, and the sectional view through the screenhouse, Fig. 2, shows the general arrangement of the later installation.

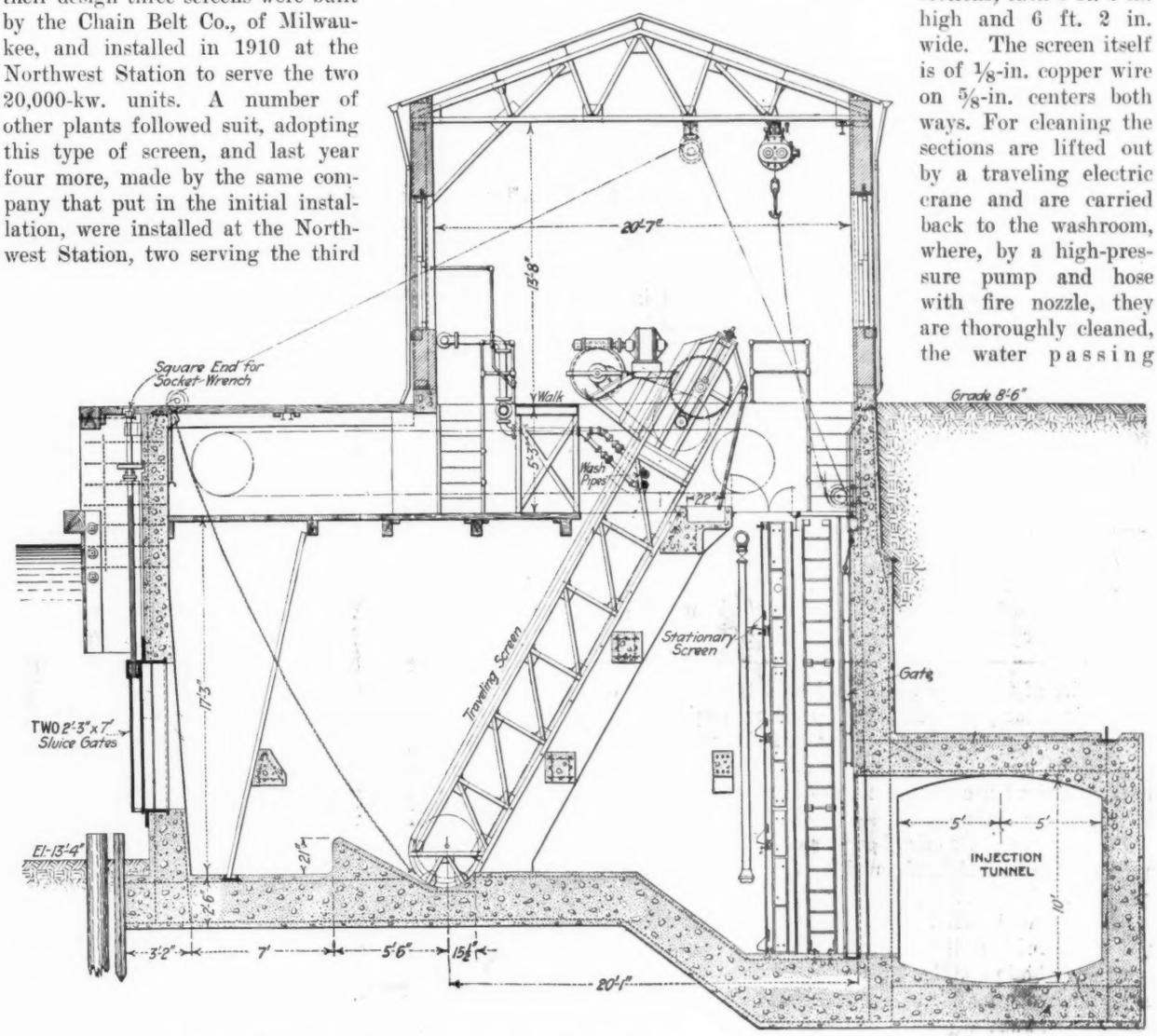


FIG. 2. TRANSVERSE SECTION THROUGH SCREEN HOUSE AND INJECTION TUNNEL

Each traveling screen is intended to serve about 15,000 kw. in generating capacity. With its frame, motor and reduction gearing it is a complete unit in itself, located in a separate compartment, or crib, between concrete walls. Water from the river is admitted to each compartment through double sluice gates 2 ft. 3 in. wide and 7 ft. high, placed side by side. They are in duplicate to facilitate hand operation, being raised or lowered by a screw and hand wheel. A heavy bar grid just inside the gates holds back the heavier floating material which may find its way to the screenhouse. The water then passes through the traveling screen, and as a single screen never removes all fibrous matter, it is the practice of the company to place one set of stationary screens with two sets of guides after the traveling screen and at the entrance to the injection tunnel.

Each set of stationary screens is made up in four sections, each 5 ft. 2 in. high and 6 ft. 2 in. wide. The screen itself is of ⅛-in. copper wire on ⅝-in. centers both ways. For cleaning the sections are lifted out by a traveling electric crane and are carried back to the washroom, where, by a high-pressure pump and hose with fire nozzle, they are thoroughly cleaned, the water passing through in a direction reverse to the usual flow.

Fig. 1 shows the seven traveling screens. Those in the foreground belong to the latest installation. The crib compartments are spaced on 8-ft. 3-in. centers, and each unit over-all measures about 30 ft. The screen itself, which is of No. 12 copper wire spaced on ⅝-in. centers both ways, is in sections 5 ft. 3 in. wide and nearly 18 in. long. These sections are reinforced all the way around with 2¼x2x¼-in. angle iron on the outside and steel bars on the inside to which the copper screen is fastened. At the corners the angle-iron frame

is notched, bent and welded to insure rigid construction. On each side these sections are fastened to a double-link endless chain equipped with 3¼-in. rollers. These chains of 18-in. pitch pass over 36-in. sprockets top and bottom, the rollers running on a leg of the angle-iron framework to support the screen sections in the 25-ft. 6-in. span between the sprockets.

Through chain belts and a reduction gear the screen is revolved by a 5-hp. motor. As apparent in Fig. 1, the motor is mounted horizontally on a base secured to the framework of the screen. The temporary wiring appearing in the photograph has been replaced by conduit. Due to the dampness all insulation is waterproofed. The motor is of the slow-speed induction type taking three-phase 60-cycle current at 220 volts.

Profiting by several years' experience with the first installation, the new screens were made somewhat stiffer and heavier all the way through. A decided improvement in the method of removing the screen from the water for repair is evident. Instead of hoisting the screen out vertically, requiring considerable headroom, the new units are pivoted at a point 2 ft. 6 in. above the new floor level and are arranged to be turned bodily to a horizontal position by the sheaves indicated in the drawing and the electric hoist previously mentioned. The floor may be removed for this purpose. The screen is then easily accessible and in a position convenient to work on.

At intervals, depending upon the quantity of leaves or débris in the water, the screen is revolved, the speed of operation being 10 ft. per min. As will be evident, the screen inclines from the vertical and by the aid of a bucket-shaped section of sheet metal attached to the lower angle iron of each section, the material collected is carried up over the top and dumped into the trench shown in Fig. 2. Just above the trench a continuous spray of water from a pipe running back of the screens removes the material that may still adhere. From the trench it is flushed into a drain line, which discharges into the river some distance downstream.

Lips attached to and projecting downward from the metal pieces at the bottom of the screen sections cover the joints between the divisions of the screen and prevent material working through at these points.

After five years of service the first screens are still giving good service. An indication of their efficiency was the installation of similar units at Fisk Street Station and the recent addition under description. The success of this type of screen is assured, and its adoption is becoming quite general.

Induction-Motor Characteristics

By H. M. Phillips

SYNOPSIS—A discussion of the speed limitations, the starting current and torque of the squirrel-cage motor, and the advantages of the wound-rotor type for certain kinds of service.

In spite of the large number of induction motors now in service, comparatively few operating engineers are familiar with their characteristics. Most isolated plants operate on direct current, but with the increase of central-station service has come greater use of alternating current and the induction motor.

In selecting the squirrel-cage motor for any specific purpose, one is first confronted by the limited choice of speeds. Although it is generally preferable when buying a direct-current motor to accept one of the standard speeds offered by the manufacturer, it is very little trouble to obtain one that runs at any desired speed; after installation one may increase the speed to a considerable extent by means of a field rheostat or decrease it by means of resistance in the armature circuit, although the latter procedure is generally objectionable. No such latitude is possible with the squirrel-cage motor. Most alternating-current circuits operate at 60 cycles, thus fixing the maximum speed for which the motor can be designed as 3,600 r.p.m., which is too high for ordinary purposes; only such lower speeds are obtainable as can be derived by dividing this figure by an even number, giving 1,800, 1,200, 900, 720, etc. It is seldom practicable to go below the last figure, the use of which is generally confined to large motors. A smaller number of circuits operate at 25 cycles, with a corresponding reduction in motor speeds, and an extremely limited number operate at 50 cycles or other odd values. The foregoing are "synchronous" speeds, practically those at which the motor will run on no load; when fully loaded, the "slip" will reduce the motor speed from 2 to 8 per cent. below these values.

This lack of flexibility in speed is not without its advantages. The shunt-wound direct-current motor invariably increases its speed with its temperature. This accession may be as high as 15 per cent. during the first few hours after starting up. The speed is also subject to minor variations in the adjustment of the brushes, and in some poorly designed motors it advances slightly with increase of load. Changes in line voltage also produce variations in speed, and if the change is sudden, there are violent current fluctuations which may throw the circuit-breakers. Although these faults do not prove very serious in practice, they are entirely lacking in the squirrel-cage motor—it cannot run away, there is a predetermined variation between no load and full, and the ordinary variations in temperature and in line voltage have no perceptible effect on the speed. Variations in frequency, which can be produced only by variations in the speed of the generator from which the power is obtained, will produce corresponding variations in speed, but these are rarely of serious magnitude.

The ability of a shunt motor to handle an exceptionally heavy overload of short duration rests in the commutator and brushes. There may be violent sparking, but no great reduction in speed until an arc forms across the commutator, blowing the fuses or doing more serious damage. No very accurate data are obtainable as to the amount of overload that may be safely carried in this manner. A modern motor should be able to stand at least twice the rated load, and it is probable that some will stand four

times full load for a few seconds. If the load is suddenly applied and is greater than the motor can carry, it is likely that serious damage will be done before the fuses have time to blow; the circuit-breaker gives better protection, but even that sometimes fails.

Under similar conditions there is a more clearly defined limit to the pulling ability of the squirrel-cage motor; few will fail at less than double load, while some will carry three times full load or even more. These figures do not differ materially from those of the shunt motor; it is the manner of failure that is of greater interest. Up to the limit of its strength the squirrel-cage motor suffers a small reduction of speed and may become slightly noisy, but gives no other sign of trouble. Having reached the limit, it quietly gives up, relaxes its pull and comes to a standstill where it will still exert some force, but very materially less than it did while running. If the motor is of small capacity, say 10 hp. or less, it may stand for half a minute with full voltage on its terminals without being damaged by the heating of its windings; which should give ample time for the fuses to operate. The maximum pull that the motor can exert while running is termed the "pull-out torque," and it is customary for the manufacturer to guarantee that it will be a certain number of times the full-load torque.

To the operator of direct-current machines a stationary motor connected directly across the line is practically the same thing as a short-circuit; and serious damage, either to the motor or elsewhere, can be averted only by the almost instantaneous operation of the circuit-breaker. The squirrel-cage motor, when so placed, may take from four to six times the full-load current, which, however, is quite different from that of a short-circuit.

Direct-Current Motor Starting Under Load

In starting a heavy load the direct-current motor has a decided advantage; with a controller designed for the work in hand it can be accelerated as slowly as desired and can be made to exert a starting torque several times that required at full load, which is sometimes of importance in overcoming the static friction of a very "dead" load. With the ordinary hand starter the direct-current motor will exert about one and one-half times full-load torque at the moment of starting. Moreover, the motor requires but twice the full-load current to give twice the full-load torque while starting, and the same proportion holds for other values. The ordinary squirrel-cage motor will exert only from once to twice full-load torque in starting even if it be thrown directly across the line, and will probably require a starting current of from two and one-half to five times full-load current to exert a starting torque equal to that required at full load.

Although a change in voltage has less effect on the speed of a squirrel-cage motor than on a direct-current motor, it has a greater effect on its ability to handle heavy loads. A moderate reduction in voltage, say 10 per cent., will probably not reduce the ability of a shunt motor to start or carry an excessive load by more than 5 per cent.; it will have no effect at all on the series motor other than to reduce the speed. With the squirrel-cage motor both the starting and the pull-out torques vary as the square of the voltage, so the reduction of 10 per cent. in voltage would give a reduction of 19 per cent. in torque. As the drawing of heavy currents is likely to reduce the line voltage, this point is of some importance.

No one would think of starting a 1-hp. shunt- or series-wound direct-current motor by throwing it directly across the line; even if the motor withstood the current, the shock would probably be too great for the machine it was intended to drive. Yet squirrel-cage motors up to 5 hp. are invariably started in this manner, and 10 hp. motors frequently are. If the fuses are of sufficiently low capacity to be of much benefit, they are pretty sure to be blown unless the squirrel-cage motor comes up to speed quickly; for which reason a double-throw switch is frequently used in starting. With the switch in position for bringing the motor up to speed, the fuses are cut out of circuit; when speed is attained, the switch is thrown over, bringing the fuses into the circuit. If the switch is so arranged that it is necessary to hold it in while in the starting position, there is no danger of the motor being left running without fuses.

Starter Necessary with Larger Motors

With the larger motors it becomes necessary to use a starter, as much to protect the line from excessive currents as for the protection of the motor itself. Starting is effected by reducing the voltage on the motor, thus cutting down the maximum current. If the motor is to be reasonably strong in starting, this reduction cannot be very great, as the current is reduced in direct proportion to the voltage, while the starting torque is reduced as the square of the voltage. Thus if the motor will give a starting torque of one and one-half times full-load torque on full voltage and it is desired to start with full-load torque, it will be necessary to apply 82 per cent. of full-load voltage. This will bring the motor up to very nearly full speed, so there is no necessity for a number of steps such as are used with a direct-current motor; and as soon as the motor approaches full speed, it is thrown directly across the line. Resistance is sometimes inserted in at least two and preferably three of the wires leading to the motor, but in most cases transformers are used; these are preferable, as they reduce the starting current in the line to a value less than that required by the motor. These transformers are generally supplied with connections for several different voltages, so that if the motor is always to start under a light load a lower starting voltage can be obtained. Even with transformers the fuses are cut out while starting.

Where Squirrel-Cage Motor Is Not Suitable

From the foregoing it will be seen that the ordinary squirrel-cage motor is not well-adapted for service that requires frequent starting and stopping, a high starting torque, a considerable time for acceleration, or suddenly applied loads. Certain classes of work performed on the hand screw machine or small engine lathe require only a few seconds for the actual cut and hardly more time to place a new piece in the chuck, the machine being started and stopped at each operation. Some large planers have their feed operated by a direct-current motor that is started and stopped with each stroke. The heavy starting current required by the squirrel-cage motor would cause it to overheat on such work. Conveying machinery that has been stopped while loaded, or a reciprocating pump working against a low head, may require double the full-load torque to start; and unless the motor is much larger than is required to carry the running load, it will be unable to start. A centrifugal machine or any

machine with a heavy flywheel may require a rather heavy pull to start and must have considerable time in which to come up to speed. Supposing the typical squirrel-cage motor to be thrown directly across the line under such service, it may exert one and one-half times full-load torque in starting and at the same time take five times its rated current; as it gains speed, the torque will increase and the current diminish, but when the motor is within 3 per cent. of its full-load speed it will still be taking twice its rated current. This heavy current, prolonged for the time necessary to bring the flywheel up to speed, is likely to produce undue heating of the motor. With direct current a compound-wound motor is generally used on shapers and planers and on machines equipped with flywheels, in order that there may be a slackening of speed with the sudden increase of load, giving opportunity for the flywheel to give up its stored energy or for the parts to be accelerated without too great an expenditure of energy. The squirrel-cage motor, with its small change of speed with load, will be subjected to a heavy overload at each stroke of the planer or at each operation calling for the expenditure of flywheel energy.

Changing Squirrel-Cage Motor Characteristics

All of the troubles previously noted can be at least partly overcome by increasing the resistance of the squirrel cage itself—that is, the rotor. The increase of resistance may be accomplished by reducing the cross-section of the end rings, by making them of a composition of higher resistance than copper or by using a metal of higher resistance for the bars themselves. To alter the section of the bars would introduce the necessity of thicker insulation or a change in the size of the slots. Increasing the rotor resistance reduces the current that the stationary motor will take at a given voltage and at the same time increases the starting torque; it also slightly reduces the pull-out torque, but the change is generally so small as to be of little consequence. It also slightly reduces the full-load speed of the motor and increases the variation of speed produced by a given change of load. The difference between the synchronous speed and the full-load speed, expressed as a percentage of the former, is termed the "slip" and measures the loss of power in the rotor, being closely analogous to the slip of a belt. If the high-resistance rotor increases the slip from 4 to 7 per cent., the motor will have lost 3 per cent. in efficiency.

Where the squirrel-cage rotor, even with high resistance, fails to produce the desired results a "wound rotor" may be used. Here the rotor carries a winding somewhat resembling that of a direct-current armature except that in place of a commutator there are three rings (in the case of a three-phase motor) to which three sets of external leads are connected by brushes. These leads have no connection with the line currents, but resistance introduced between the terminals has the same effect as increasing the resistance of the rotor; with the advantage that it can be varied by a controller to suit the requirements of the service. By its use a starting torque equal to full-load torque can be obtained with a current only slightly exceeding that required while running at full load; with a lower resistance the starting torque may be made equal to the pull-out torque with a proportional increase of current. The acceleration is under the control of the operator, and the motor may be run indefinitely at as slow a speed as required, with a corresponding loss in efficiency.

For machine tools requiring to be driven at different speeds, the induction motor offers no very acceptable substitute for the shunt-wound motor with field control. The introduction of the wound rotor causes a loss of efficiency on low speeds and gives a wide variation of speed with changing load. Two speeds are sometimes obtained by the use of two windings, really combining two different motors in one, but the performance sometimes fails to be very satisfactory. Motors with commutators, generally single-phase, are sometimes used for small powers, but fail to show all the desirable qualities of the three-phase motor.

The operator on first acquaintance with induction motors may be surprised to find that they take from one-quarter to one-half full-load current while running at no load. This does not mean that they require the same proportionate amount of power, but merely that they have a low power factor; the actual power will rarely exceed 10 per cent. of full load and may be considerably less. In most cases this is of little importance, but if a large number of such motors are kept running light for a considerable part of the time, a generator must be provided with sufficient current capacity to supply this relatively high no-load current. Under full load the power factor is usually from 80 to 90 per cent., which fact also must be considered in calculating the current capacity of the generator.

In speaking of induction motors, the stator winding is often referred to as the "primary" winding and the rotor winding as the "secondary."

Vacuum-Pump Test Results

By Henry A. Cozzens, Jr.

Great claims are made and demonstrated in shop tests by the builders of hydraulic air pumps, but they should also be tested in actual operation. A few calculations

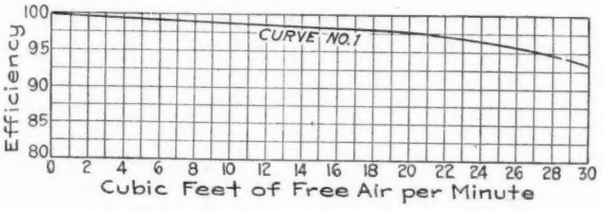


FIG. 1. EFFICIENCY AT VARIOUS RATES OF DELIVERY

and results will illustrate the use of the various terms encountered in air-pump tests.

An air-pump guarantee reads somewhat as follows: "With all exhaust piping free from air leaks and at the specified speed, we guarantee this pump to be capable of handling 20 ft. of free air per minute with 70-deg. hurling water and with 28.5 in. vacuum."

One method of testing is to admit air into the air line through an orifice or venturi tube. The communicating valve between the pump and the condenser is tightly closed to prevent leakage of air or vapor from the condenser. The temperature of the hurling water is observed, and the vacuum is measured with a mercury column.

The purpose of the following test was to determine whether the pump met the guarantee under the operating

conditions when the temperature of the hurling water was 39 deg. The test showed the following results:

Run	Vacuum In. Hg.	Volume Air, Cu.Ft. per Min.
A	29.72	0.0
B	29.52	7.6
C	29.38	10.6
D	29.07	16.9
E	28.74	21.9
F	28.49	24.4
G	28.27	26.9
H	28.02	28.8
I	27.88	29.8

Run *A* was with the entrance valve closed and is what is called the shutoff or closed suction; on the others the valve was gradually opened, admitting air into the line.

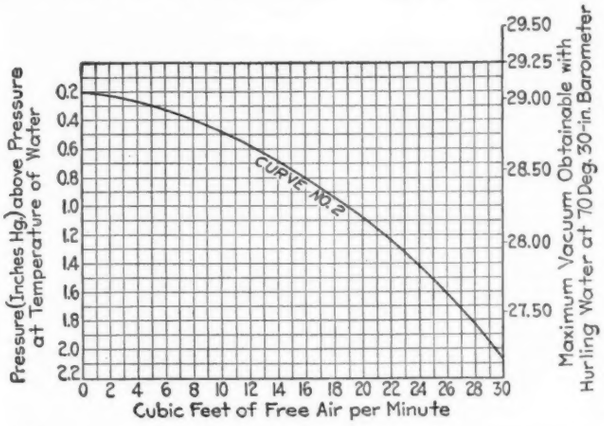


FIG. 2. PERFORMANCE UNDER VARIOUS CONDITIONS

The efficiency of an air pump is the ratio between the vacuum obtained (30-in. bar.) and the vacuum due to the temperature of the hurling water. The maximum vacuum obtainable at 39 deg. is 29.76 in., and hence that is taken as the standard. For run *A* the efficiency is $\frac{29.55}{29.76} = 99.3$ per cent. The efficiencies for the other runs are found plotted against the free air delivered in curve 1.

The admission of air to the pump impaired the vacuum, causing it to gradually fall off. The pressure existing in the suction line is the difference between the barometer reading and the observed vacuum, as for instance, in run *F* the vacuum 28.49 in. subtracted from the barometer reading of 30.17 in. gives a total pressure of 1.68 in., having two components—one due to the presence of the air and the other due to the water vapor at the given temperature in accordance with Dalton's law that when two gases or vapors are mixed in a given space, the pressure is the result of the partial pressure that each would exert if it occupied the space alone. It is a simple matter to obtain the pressure due to the water vapor when the temperature is known; thus at 39 deg. the pressure would be 0.24 in. of mercury.

Referring again to run *F*, the total absolute pressure in the pump was 1.68 in., of which 0.24 in. was due to the water vapor and the difference, or 1.68 — 0.24 = 1.44 in., was then due to the presence of air; that is termed the partial pressure. The following table shows the different pressures:

Run	Vacuum	Total Absolute Pressure	Partial Pressure Due to Air
A	29.72	0.45	0.21
B	29.52	0.65	0.41
C	29.38	0.75	0.51
D	29.07	1.10	0.86
E	28.74	1.43	1.19
F	28.49	1.68	1.44
G	28.27	1.90	1.66
H	28.02	2.15	1.91
I	27.88	2.29	2.05

In curve 2 these partial pressures are plotted against the volume of air handled, and this curve denotes the performance of the pump under the test conditions. These results must be equated to the guaranteed 70-deg. hurling water. With 70-deg. hurling water and a 30.0-in. barometer the maximum obtainable vacuum would be 29.26 in. If no air were present, there would be no "partial pressure" due to air alone and consequently the value zero for the partial pressure on the ordinate and the maximum vacuum 29.26 in. would coincide, resulting in fixing 29.26 opposite 0 partial pressure. The remaining points on the ordinate are obtained by subtracting the partial pressures from the maximum vacuum. It has become quite common practice to eliminate the partial-pressure figures and quote the results in terms of the maximum vacuum obtainable with the hurling water at the specified temperature.

Some quote the pump performance as handling a certain amount of free air against a partial pressure of so many inches, as in the case just cited—a pump handling 20 ft. of free air per minute with 70-deg. water against a partial pressure of 0.76 in.

Weld Repair to Engine Frame

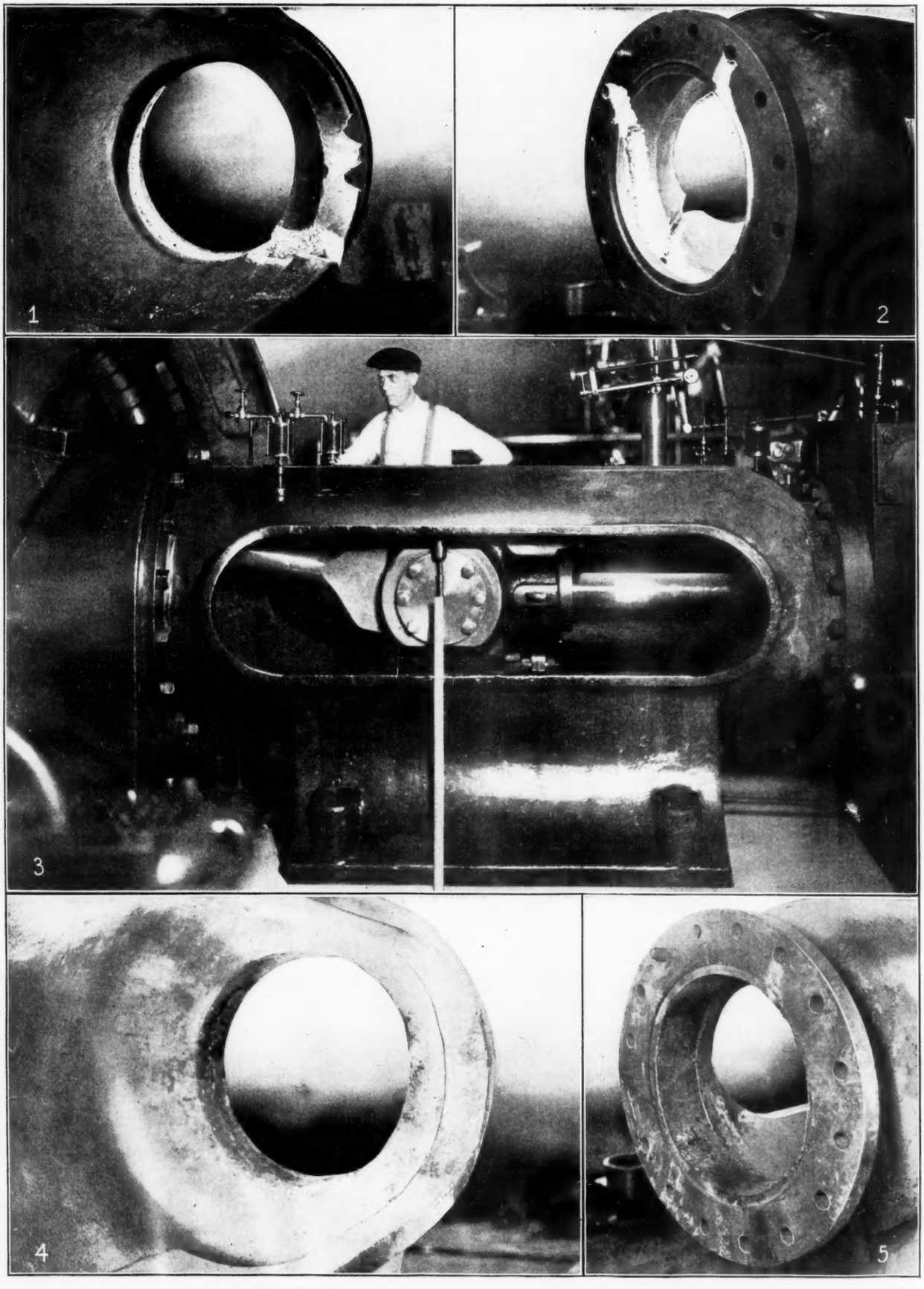
SYNOPSIS—The crosshead barrel of a 1,200-hp. Corliss engine cracked next to the cylinder-end flange for about three feet. The casting was repaired by welding.

As a result of the settling of the cylinder foundation the crosshead guide barrel on the high-pressure side of a 1,200-hp. cross-compound Corliss engine cracked. The fracture extended about one-third around the flange (about 3 ft.) bolted to the cylinder casting. There was also a crack extending from the flange to the opening in the side of the casting, which was about 2¼ in. thick.

The practical method of making a lasting repair was by welding. The guide barrel was removed from the engine and chipping with an air-driven chipping tool was begun at about 10 a.m. on a Tuesday. It was past midnight before the casting was ready for welding. Figs. 1 and 2 show the crack chiseled out ready for the welding torch.

An oil torch was applied to the cracked portion of the casting and a charcoal fire placed in a firebrick furnace around the same end, so that welding could start the next day. The job itself occupied about six hours, but owing to the necessity of stopping to heat the casting it was about 10 p.m. Wednesday before the work was completed. Figs. 4 and 5 show the casting after welding. Fig. 3 is the casting back on the engine, ready for service.

In order to produce a gradual lowering of the temperature of the casting the firebrick furnace was not removed until noon on Wednesday.



HOW THE ENGINE GUIDE BARREL WAS CRACKED AND WELDED

Figs. 1 and 2—Showing crack chipped ready for welding. Fig. 3. Guide barrel back on engine. Figs. 4 and 5—Same casting after welding

The job used about 610 cu.ft. of oxygen and practically the same amount of acetylene, 70 lb. of ½-in. cast-iron filling rod and about 3½ lb. of iron flux. The cost of the work and material was as follows: Filling rod and flux, $4; oxygen and acetylene at 2c. per cu.ft., $24.40; labor, $42.80; total, $71.20.

About 100 cu.ft. of oxygen was used per hour and about the same amount of acetylene. The cost to the owners was $235, excluding the labor of their own men, who removed the casting from the engine and replaced it after the completion of the welding, which was done by the Prest-O-Lite Co.

Indicating the Ammonia Compressor--II

By Robert H. Karl*

SYNOPSIS—Second of a series of articles on how to indicate the ammonia compressor and correctly read what the diagrams tell. This article shows the importance of the isothermal curve for judging how perfect is the expansion line of the indicator diagram. Number one article fully explained the adiabatic curve and its use.

If the heat of compression could be removed as fast as generated—that is, if the temperature could be kept constant—then the indicator would trace the isothermal line and there would be a considerable saving of work, but this cannot be done; the temperature should, however, be kept as low as possible by the proper circulation of sufficient jacket water.

The isothermal curve is more easily calculated than the adiabatic curve by using the formula $pv = p_1v_1$, which is the law of isothermal expansion or compression; that is, the initial pressure times the initial volume is equal to the final pressure times the final volume. The diagram is divided and vertical division lines erected the same as for the adiabatic line.

Assume the point *a*, Fig. 8, as the starting point. At this point, $p = 30.7$ lb. and $v = 1$. When the volume is reduced to 0.9 of the original volume, or when $v_1 = 0.9v = 0.9 \times 1 = 0.9$, the corresponding pressure is found from the formula $pv = p_1v_1$. Substituting the values of $p = 30.7$, $v = 1$ and $v_1 = 0.9$, the formula reduces to $30.7 \times 1 = 0.9 \times p_1$, from which $p_1 = \frac{30.7}{0.9} = 34.1$ lb. Now lay off this pressure on the vertical line 0.9 and proceed in the same manner for 0.8, 0.7, 0.6, etc. Fig. 8 shows a diagram where this is done. Thus, when

$v_1 = 0.8p_1 = 30.7 \div 0.8 = 38.8$ *lb.*
$v_1 = 0.7p_1 = 30.7 \div 0.7 = 43.8$
$v_1 = 0.6p_1 = 30.7 \div 0.6 = 51.1$
$v_1 = 0.5p_1 = 30.7 \div 0.5 = 61.0$
$v_1 = 0.4p_1 = 30.7 \div 0.4 = 76.5$
$v_1 = 0.3p_1 = 30.7 \div 0.3 = 102.3$
$v_1 = 0.2p_1 = 30.7 \div 0.2 = 153.3$

By laying off these values of p_1 as ordinates for the corresponding volumes, the points for the curve are located and a curve *ad* drawn through these points will be the isothermal curve.

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While the adiabatic curve is the true guide for comparison of the compression curve, the isothermal curve in addition to the adiabatic gives it a more definite location and better comparison.

A compression curve may appear all right, yet when the true adiabatic and isothermal curves are drawn, it will at once become apparent whether it is defective or not.

The adiabatic curve will be taken up first (see Fig. 4).[1] Notice that the compression line is above the adiabatic line. This indicates that the pressure in the cylinder increases faster than could be caused by the mere compression of the gas by the piston. The reason is that high-pressure gas is leaking into the cylinder through leaking discharge valves, their gaskets, or through the cylinder-head gasket between the discharge port and the cylinder.

It is evident that if this condition exists, the cylinder is not getting its full charge of gas and therefore not enough gas is pumped. It is evident from the increased area of the diagram that it requires considerable power

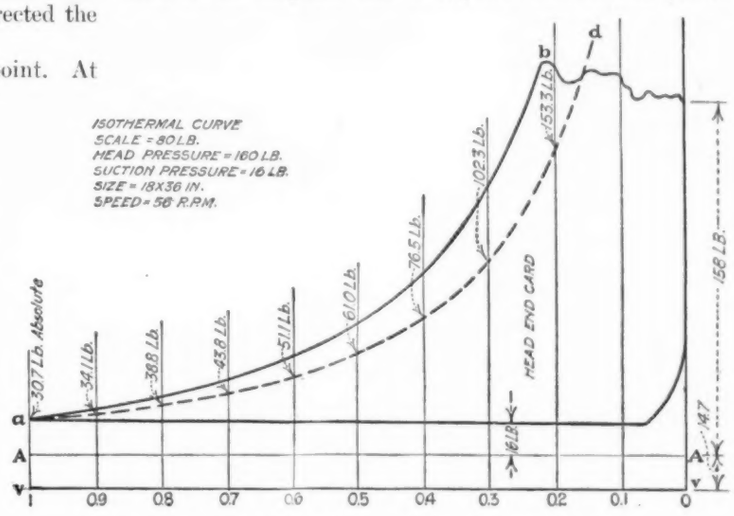


FIG. 8. THE ISOTHERMAL CURVE SHOWN DOTTED

to run the compressor. This means a loss, and it does not take long for a compressor to waste much fuel if allowed to run in this condition.

The valves should be removed, the cylinder head taken off and all gaskets carefully examined and, if found defective or looking bad, replaced with new ones. If the machine has no valve-cage gaskets but has ground joints, regrinding may be necessary to get a tight joint. The

[1]Article I, "Power," Apr. 25, 1916.

joint may be all right, but the valve cage may have worked loose, causing the seat to leak. The valves might leak and require regrinding. Generally, an inspection of the valve seats and disks will show if any are leaking. One will generally find the valve seat and disk pitted, caused by scale from the pipe system. Pieces of this scale will lodge on the valve seat and the continual closing of the valve on the small hard pieces will cause the seat and disk to become pitted with numerous small holes. This condition may not exist, but a careful examination of the valve seat will show whether the bearing surface is good or bad. It may be possible that there is a poor bearing surface caused by the valve disk not seating true. Whatever the cause, the valve should be put in good condition and reground if necessary. After regrinding, it can be tested for tightness by placing on a table in an upright position and filling it full of gasoline, letting it stand for a few hours. If it will hold gasoline it is tight.

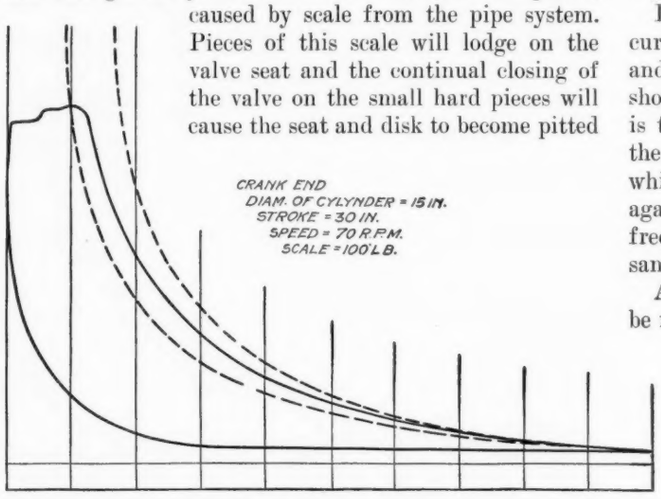


FIG. 9. FROM A MACHINE WITH A SCORED CYLINDER

All compressors should have an extra set of valves kept in first-class condition, so that any defective valve can be replaced in a short time. Do everything possible to remedy the trouble and then take more diagrams. Draw the adiabatic line, and if the compression curve is still above the adiabatic, you have not remedied the trouble. If you have no indicator, you may make the test by connecting a pressure gage to the indicator connection and allowing the condenser pressure to act upon the outer faces of the discharge valves. If the pressure as shown by the gage remains the same or increases very slowly, you have remedied the trouble, but if it increases rapidly, you have not.

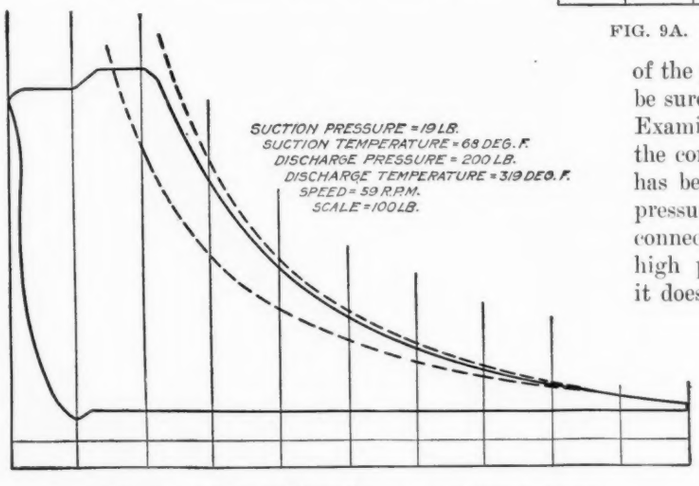

SUCTION PRESSURE = 19 LB.
SUCTION TEMPERATURE = 68 DEG. F.
DISCHARGE PRESSURE = 200 LB.
DISCHARGE TEMPERATURE = 319 DEG. F.
SPEED = 59 R.P.M.
SCALE = 100 LB.

FIG. 10. HIGH-PRESSURE GAS LEAKING BACK INTO CYLINDER

Referring to Fig. 5, it is seen that the compression curve falls away rapidly toward the isothermal curve, and the reason is that the pressure is not as great as it should be at any point on the curve. The cause for this is that some of the gas has leaked out of the cylinder; the piston, the suction valves, some gasket or joint leaks, which causes part of the gas to be pumped over and over again, thereby reducing the capacity of the machine. It frequently happens that all of these defects exist at the same time.

A careful examination of all gaskets and joints should be made. If it is found that the valves leak, they should be ground in; the cylinder should be calipered to see if it is truly round, and if found out of round, badly cut or scored, it should be rebored and new piston rings fitted.

The piston and rings should also be carefully examined. A new set of piston rings might be necessary, and they should be a good fit in the grooves of the piston. If the piston rings are set out with springs, be sure that they are all right and in the proper position. Examine the valves and cylinder carefully, after which the compressor should be indicated to be sure the trouble has been corrected. In the absence of an indicator the pressure gage may be used by attaching it to the indicator connection; then compress the gas in the cylinder to a high pressure and note the reading on the gage. If it does not decrease or decreases very slowly, the trouble has been corrected. If it decreases rapidly, another examination should be made.

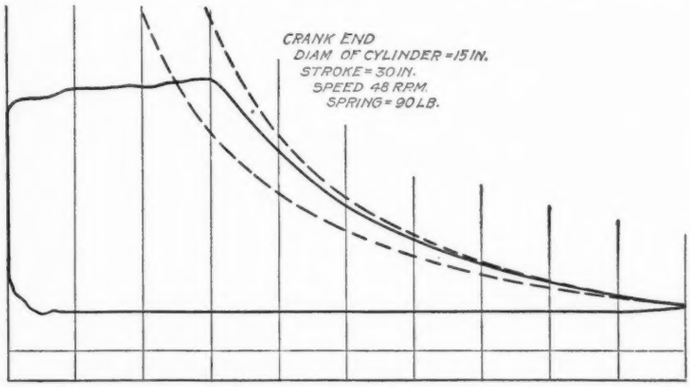


FIG. 9A. TAKEN AFTER THE CYLINDER WAS BORED

In making an analysis of an indicator diagram from an ammonia compressor, any deductions are apt to be misleading unless one is familiar with all conditions at the time they were taken; for, as stated in the first article, conditions are influenced by many factors.

Aside from the foregoing, experience has taught me that it is necessary to have an intimate knowledge of the construction of the compressor from which the diagrams were taken and a knowledge of the indicator used and the engineer who used it.

The careful operator will be sure to wipe clean and dry the indicator and its parts and finally wipe them with an oily cloth before putting them away.

When an engineer sends in diagrams for analysis and information, unless you have an intimate knowledge of the facts cited, any deductions you might make would be of questionable value.

It is well known that many defects of ammonia compressors can be easily detected without the use of an indicator; on the other hand, it is also a fact that many defects cannot be so readily detected and are brought to light only by its use. Further, experience has proved to me that 90 per cent. of the ammonia compressors in operation will show some defective condition; in fact, you will find few compressors that will give a diagram like that illustrated in Fig. 7, which indicates that the compressor was in first-class condition and properly operated.

It is sometimes confusing to the inexperienced engineer to read diagrams from defective compressors; also

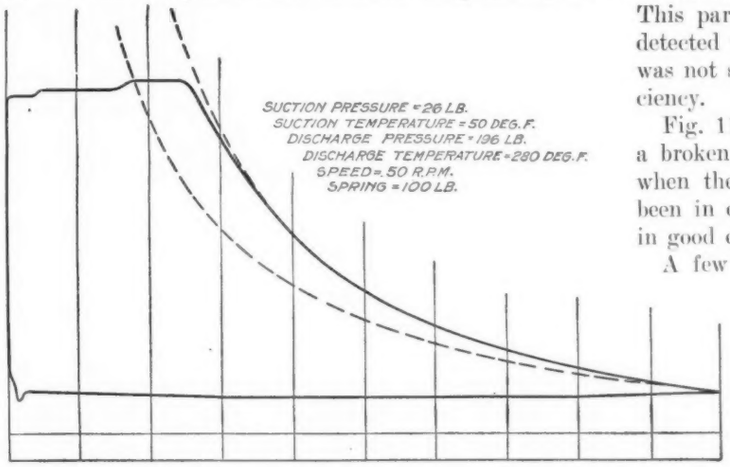

SUCTION PRESSURE = 26 LB.
SUCTION TEMPERATURE = 50 DEG. F.
DISCHARGE PRESSURE = 196 LB.
DISCHARGE TEMPERATURE = 280 DEG. F.
SPEED = 50 R.P.M.
SPRING = 100 LB.

FIG. 10A. AFTER THE DISCHARGE VALVE AND CAGE WERE MADE TIGHT

experienced engineers sometimes have considerable trouble in locating defects that are brought to light by the indicator. For these reasons numerous diagrams are illustrated showing defects that are most commonly met. A careful examination of these will assist one to make a comparison with his own diagrams. All diagrams illustrated are reproductions from actual ones taken by the writer and represent all kinds and makes of machines operating under all conceivable conditions.

Fig. 9 represents a card taken from a machine with a cut or scored cylinder. Notice how the compression curve falls away from the adiabatic curve and toward the isothermal curve, and how large is the reëxpansion loss. The suction valves were also found to be in bad condition; in fact, the whole machine was in a deplorable state. This compressor was operated in this condition for a long time before it was suspected that any defect existed, and it is needless to say that the capacity of the machine was much below normal, thereby causing a considerable loss. After reboring the cylinder and regrinding all valves and joints and renewing the gaskets, Fig. 9A was obtained. The plant where this machine was located had an indicator, but it was never used.

Fig. 10 shows a peculiar condition of a discharge valve. High-pressure gas was leaking back into the cylinder through the valve. Ordinarily when this condition exists the compression line lies above the adiabatic curve, but in this case it falls below it, the reason being that the gas during compression leaked out of the cylinder from the same source that allowed it to leak back in after discharging.

Considerable trouble was had before the cause of the trouble was located, as the valve and cage seat were apparently all right. It is customary at this plant to change valves often, thereby always having the compressor valves in first-class condition, but in making this particular valve change not quite enough attention was given to ascertain if the cage seat was true and had a good bearing; it was later shown that it did not, with the result that when the valve and its cage were securely tightened in the housing, the seat was sprung, which caused the leakage. Upon applying the indicator after remedying the trouble, Fig. 10A, was obtained.

Cases of this kind show the value of the indicator. This particular trouble is one of many that cannot be detected without its use. While it is true that the leak was not serious, still it was a leak, and leaks reduce efficiency.

Fig. 11 shows a diagram from a compressor that had a broken discharge-valve stem. The writer was present when the compressor was overhauled, and after it had been in operation a few days, diagrams showed it to be in good condition.

A few days later, while indicating other compressors in the same plant, the indicator was again applied to this same compressor, nothing wrong being suspected or noticed in its operation,

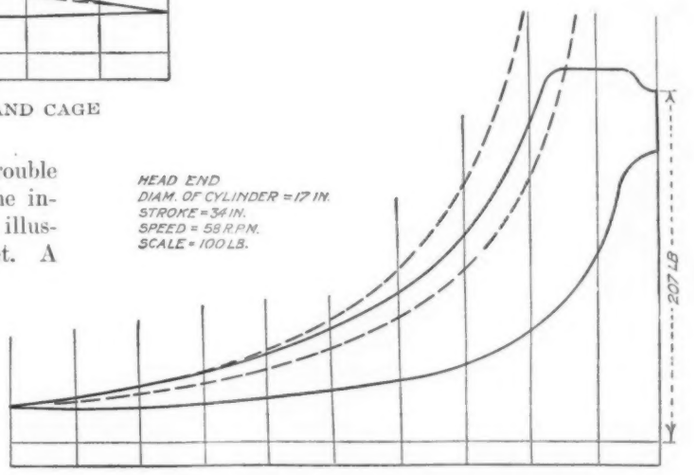


FIG. 11. THE DIAGRAM INDICATES THAT THE DISCHARGE VALVE-STEM WAS BROKEN

when the card, Fig. 11, was obtained. This is a striking illustration of the value of indicating the compressor at regular intervals.

Some engineers might argue that a broken valve stem in a compressor would make itself known to the operator immediately. Sometimes it will and sometimes it will not—it all depends upon the nature of the break, valve construction, etc. Take a plant with only a single compressor and working to the limit of its capacity. Any falling off in capacity would be investigated immediately, and perhaps a defective compressor brought to light. Now suppose the compressor was much too large for the work it was doing. With no apparent reduction in output, or in a plant where there were several machines operating, it would not be so readily noticed.

Cleaning Condenser Tubes

By C. F. Hirshfeld*

SYNOPSIS—Gain in vacuum obtained by keeping tubes clean. Of the various methods that have been employed, the author does not favor brushing or scraping, hammering or cutting or the chemical method. Baking, most commonly used in this country, gives satisfactory results, but best of all, when effective, is the washing process, which does not entail shutting down the condenser.

It is well known that turbines are particularly sensitive to variations of back pressure, showing marked increase in steam economy for comparatively small decrease in back pressure. The theoretical variation of economy is shown in Fig. 1 for steam and vacuum conditions similar to those existing in modern plants. In this figure the theoretical steam consumption per unit of output at a back pressure of 0.3 lb. is designated as 1, and the theoretical steam consumptions at higher back pressures are then expressed in terms of the consumption at 0.3 lb. Test results on the actual units would give figures showing a similar variation.

Under such circumstances it is often assumed that it is justifiable to strive for the highest attainable vacuum. This, however, is not correct. Excessively high vacuum entails abnormally high first cost and abnormally high auxiliary operating costs. The correct vacuum is that which gives the smallest total cost for power. It is set at such a point that further improvement would entail greater expenditures than are saved by reason of the resulting decreased water rate of the turbine.

Most modern plants have auxiliary apparatus capable of giving almost, if not quite, the most economical vacuum in the sense in which that term is here defined. Being so equipped, obviously they should be so operated as to take full advantage of the capabilities of the apparatus installed.

Unfortunately this is not often done, particularly where surface condensers are installed. When properly designed, a surface condenser contains the tube surface required to transmit sufficient heat to give adequate condensation and air cooling at the most economical vacuum when that tube surface is in good condition. The problem of maintaining tube surface in good condition is frequently serious.

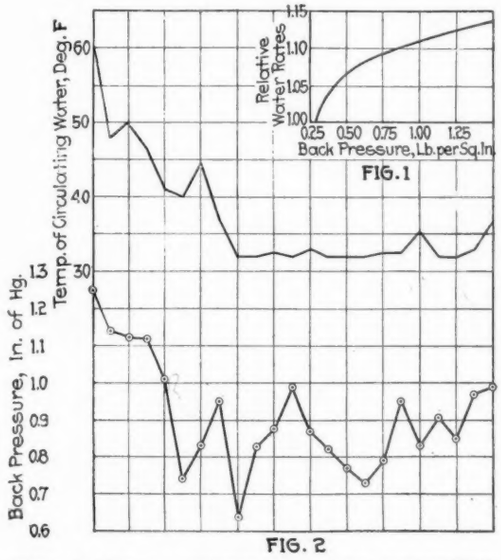
Many papers and articles dealing with heat transmission in surface condensers have appeared during the past few years. These have plainly shown that three resistances to heat flow between steam and water must be considered.

There is a certain resistance to flow of heat from steam to tube. This is greater the greater the quantity of air mixed with the steam in contact with the tube. It is also increased by any foreign matter such as oil or salty deposit on the steam side of the tube. There is also a resistance to flow of heat through the metal of the tube. This is in general very small in comparison with the other two resistances. The third resistance to heat flow occurs between the metal and the water. This is diminished by increased water velocity or by agitation of the water in any way, and it is greatly increased by deposits of foreign matter on the metal.

Probably no surface condenser is operated under such conditions that the circulating water does not deposit foreign materials of some sort on the tube surface. In power plants the water practically always flows through the tubes and such foreign matter as is deposited by the water is therefore left on the interior surface of the tubes. Until one has had an opportunity to actually measure the effect of perfectly harmless-looking deposits, it is almost impossible to realize the relatively enormous influence that they may exert upon the vacuum attainable.

The actual effect of such deposits is well shown in Fig. 2, which is a graphical record of the performance of an 18,000-sq.ft. condenser in a plant that is favored with particularly good circulating water. Each of the circles marks the back pressure obtained during a weekly test with the turbine operating at a point approximately its best water rate. The lines connecting the points have no meaning. In general the back pressure follows the circulating-water temperature, but there are numerous peaks and valleys that are obviously independent of water temperature. Invariably the prominent valleys occur at the end of a week during which the interior surfaces of the tubes were well cleaned.

The shape of the graph here given has been found to be characteristic. After a thorough cleaning there is a marked improvement in vacuum. This is often as much as 0.3 in. of mercury and occasionally as high as 0.5 in. Immediately after the cleaning the tubes begin to foul and the back pressure slowly mounts until at the end of from two to four weeks it has attained a value corresponding to that existing before the tubes were cleaned.



FIGS. 1 AND 2. CURVES OF BACK PRESSURE

Fig. 1—Variation of Economy with back pressure. Fig. 2—Effect of deposits on back pressure

Obviously the greatest steam economy would be attained if the tubes could be kept in a condition to maintain the back pressures at values approximating the low points of the valleys. This would probably not correspond

*Chief of research department of the Edison Illuminating Co. of Detroit.

to the maximum over-all economy, however, as the cleaning of the tubes involves certain expense which must be balanced against steam and coal charges. The greatest economy, all things considered, results when the tubes are maintained in such an average condition that greater cleanliness would involve expenditures so large as to reduce the net saving effected. This makes it evident that the smaller the cost of cleaning thoroughly the greater

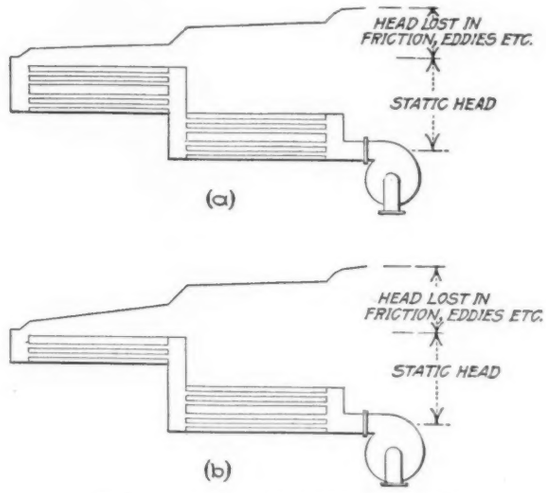


FIG. 3. SHOWING LOSS OF HEAD
(a)—Loss of head with all tubes open in both passes. (b)—Half of tubes in second pass closed

the chance for net saving in the operation of the station. Modern condensers contain thousands of small-diameter tubes, and these are often 16 to 19 ft. long. The devising of an economical method of cleaning such tubes is therefore difficult. Any process that involves opening the condenser and the individual treatment of each tube must be costly because of the labor involved and the length of time during which the unit must be idle.

So far as the author knows, five methods have been suggested and have been used more or less. These may be designated as (1) the brushing or scraping method, (2) the hammering or cutting method, (3) the chemical method, (4) the baking method, and (5) the washing method.

The Brushing Method

The brushing method was evidently inspired by those used for cleaning the interiors of the tubes or flues of fire-tube boilers. It consists in opening the condenser and running brushes or scrapers, or both, through the individual tubes. Such treatment is obviously expensive as it is no small task to properly brush or scrape the interior of several thousand small-diameter tubes with a cleaning tool having a handle 16 to 20 ft. long.

Where the circulating water deposits only large-sized, noncementing grains of material or fairly large pieces of organic matter, this method is capable of giving satisfactory results if the cost can be justified on the basis previously outlined. If, however, the deposit left by the water is such that it adheres strongly to the tube wall or that it forms a hard coating, the process is apt to be dangerous. Under such circumstances the brushes must be so hard and the scrapers of such character and fit that particles of metal are removed from the tubes with the deposit scraped out. Obviously such a treatment of condenser tubes cannot be justified on the basis of cleanliness under ordinary conditions, as it must lead to numerous tube failures in time and ultimately to the replacement of all of the tubes.

The Hammer Method

The hammer method was evidently suggested by the devices used for turbining the scale out of water-tube boilers and for knocking the scale off the outside surfaces of the tubes of fire-tube boilers. It consists in feeding a mechanical knocking or cutting device through each tube to remove the deposit from the tube wall. The broken-up deposit is later washed out of the tubes by the circulating water, or it is removed by the exhaust from the cleaning tool.

So far as the author is aware, this method has never been widely used, and it would seem that it does not hold great promise except, possibly, in a few localities where the deposit is so cemented together and to the tube as to resemble boiler scale. Under normal conditions it would hardly seem safe to subject a material like brass to the hammering and cutting action of mechanical cleaners. Moreover, this method has the same disadvantages as that previously described, in that the condenser must be opened and each tube treated individually.

The Chemical Method

The chemical method has been used to some extent in Europe and possibly in this country. It consists in feeding into or through the tubes a dilute chemical solution that will attack the deposit and leave it so that it can be easily brushed out or washed out with the circulating water. Such information as is available with regard to

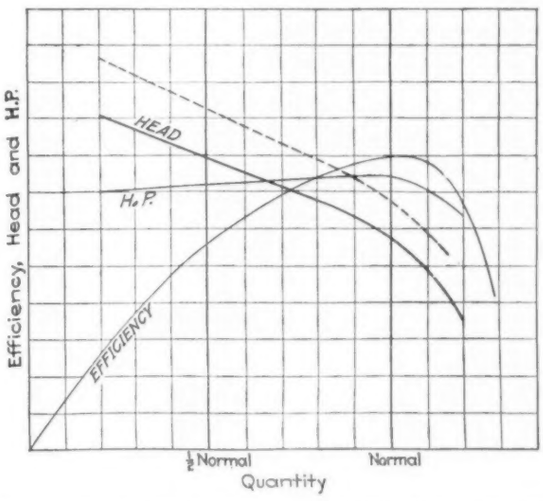


FIG. 4. CHARACTERISTICS OF CENTRIFUGAL PUMPS

this process does not indicate that it has been particularly satisfactory. The cost of chemicals combined with the danger to packings, bimetallic contacts and tube metal would seem to argue strongly against it.

The Baking Method

Baking is the method most commonly used in this country, and when properly used, it is capable of giving very satisfactory results. It depends upon the admission of steam to the steam space of the condenser while the circulating pump is shut down and the tubes are therefore not filled with water. The steam pressure is so

regulated as to subject the tubes and the deposits within them to a temperature of from 150 to 212 deg. F. After the condenser has been "baked" in this way, the deposit is washed out by the circulating water or by water from a pump giving a higher head.

The results obtained are apparently due to the interaction of a number of different things. At first the deposit is dried out. This is materially expedited if the tubes are supported at various points along their length so as to drain to the ends. The simple act of drying renders many deposits pulverulent so that they could really be blown out of the tubes by air jets if that were desirable. In this condition they are generally washed out easily with the circulating water.

Many deposits seem to be bound together by living or dead organic matter. The baking seems to loosen the bonds in some way so that the deposit, which, before baking, formed a smooth sheet, breaks up into flat and curled flakes. These are more or less easily washed out with water.

Expansion of Tubes and Deposits

In any event the coefficients of expansion of tube and deposit are almost certain to be different, and if the deposit has any degree of coherence, the mere act of raising the temperature of both should break the two apart by virtue of the differential expansion.

When the deposit is such that after baking it can be effectively washed out by the circulating water, this process is effective and cheap. When the deposit is such that high-pressure water is required to free it, the expense of cleaning is materially increased, as the tubes must be washed individually or in small groups by a cluster of nozzles.

In using this method of cleaning great care is necessary during the initial stages of the baking process. The temperature in the steam space of the condenser should be raised slowly so that the large masses of metal forming the shell and other parts may have time to heat and expand uniformly. The baking period should be of such length as is shown by experience to give the best results. It will generally be found that from one to five hours will be necessary to completely dry and loosen the deposit.

The Washing Process

Any deposit could be removed from a tube by forcing water through that tube at a sufficiently high velocity. Sometimes a water velocity less than twice that occurring during operation is enough to remove the deposit left in the tubes.

Experiments made along these lines have led to a cleaning method that was recently patented in Germany. According to these patents the water heads of the condensers contain flap valves or other devices that can be closed over the ends of various banks of tubes in such order and to such an extent as the operator deems desirable. By closing off a certain fraction of all the tubes, the circulating water is compelled to flow through those remaining open, and if the circulating pump is capable of giving the required pressure, the open tubes can often be effectively cleaned out in this way.

If a reciprocating circulating pump were used, it would generally be possible to obtain the required velocity in the open tubes. With centrifugal circulating pumps, which are now more commonly used, the possibility of obtaining greatly increased velocity depends upon the characteristics of the pump.

The losses occurring at entrance to and exit from the tubes, as well as those that take place within the tube, vary approximately with the second power of the velocity, so that double the velocity would cause a loss of head four times as great as that occurring during normal flow. It is always true, however, that the loss of head during flow through one pass is only a part of the total loss of head occurring during the entire flow through the condenser and the fact that the head lost in flowing through one pass is roughly quadrupled when the flow through that pass is doubled does not mean that the head created by the pump must be quadrupled.

This is shown diagrammatically in simple form in Fig. 3. The upper and lower passes of a two-pass condenser have been separated by turning the upper half 180 deg. in a horizontal plane, so that a diagram of heads can be drawn as a continuous line. In *a*, Fig. 3, both passes have all tubes open. In *b*, half the tubes in the second pass are assumed to be closed off, but the same total flow of water is assumed. For the sake of simplicity all pipes and water heads have been assumed to have the same sectional area as the normal bank of tubes, so that no changes of velocity need be considered except in the second pass in the second case. It will be observed that the total head required at the discharge of the pump in the second case is only slightly greater than that required in the first case.

Centrifugal Pump Characteristics

In any new construction a centrifugal pump with the desired characteristics could probably be chosen; in an old installation the possibilities of the pump must be determined by experiment. The normal characteristics of centrifugal pumps are shown in Fig. 4. The head-quantity characteristic shows a material increase in head, as the quantity discharged varies from the normal amount to half the normal amount. With one-half of any bank of tubes shut off, any quantity above half-normal will give a velocity through the open tubes of that bank greater than normal. At the same time the horsepower-quantity curve shows that the horsepower required would decrease slightly.

Greater velocity could be obtained by closing off two-thirds of the tubes of one bank if the characteristics of the pump happened to be favorable—that is, if the head-quantity curve continued to rise rapidly enough toward the left. Still further increase of velocity through a partly closed bank could be obtained by increasing the speed until the head-quantity characteristic became as shown by the dotted line. Under some circumstances increase of velocity might be readily possible; under others the design of the machine driving the pump might make such increase impossible.

The washing of tubes by partly closing the various banks in the condenser has the decided advantage that it can actually be done during normal operation and that it involves a minimum expenditure for labor. With properly chosen apparatus it should be the most economical method when the deposit will yield to such treatment. When it will not, probably a combination of such a washing process with the baking process previously described would prove satisfactory.

Future of the Private Plant

By J. A. McHollan

SYNOPSIS—An analysis of some of the factors entering into the central station vs. isolated plant problem, the relation of the operating engineer to the cost of production and the operating company as a possible solution.

Although the independent power plant is still a powerful economic factor in the supply of electric energy to large buildings in New York City, the situation is undergoing radical changes that are of far-reaching importance to the operating engineer. These changes are being brought about by increasing costs of labor and fuel, by improved methods of electric lighting, by the introduction of more economical machinery, by successive reductions in the cost of electric energy offered by electrical corporations and, to a minor degree, by the campaign of central-station interests against the independent power plant.

The last item is the least important. As a matter of fact, the operating engineers ought to feel thankful for the unintelligent and ineffective methods by which the electrical interests seek to persuade building owners that the operation of electrical machinery is not productive of economy. The other causes, however, contribute directly to the obsolescence of electric power plants and constitute a real menace to their future existence.

Engineers Ignore Commercial Aspects

Consulting as well as operating engineers often fail to appreciate the fundamental conditions that justify the operation of power-plant machinery and appear unable to set forth their conclusions in a way that a business mind may grasp easily. No other proof of this statement is needed than to peruse the customary report on power plants or operating costs. In such presentations, the commercial aspect of the problem is ignored, technical details are emphasized, constructive suggestions and logical conclusions are usually missing. This lack of a clear understanding of the problem is by no means confined to those who advocate the operation of private plants; it is as prevalent among engineers who represent the commercial interest of electrical corporations. But there the comparison ceases. Behind the operating engineers there are not thoughtful executives to interpret the attitude of the parties to whom electricity is to be furnished, upon whose decision the methods of operation are to be determined. The operating engineer is without such assistance and finds himself embarrassed by his wealth of knowledge of technical details, his inability to express his thoughts and his ignorance of what is essential and what is not.

On the other hand, those who direct the campaign of the central station understand fully the problem with which they are confronted in the private power plant. The problem to them is clearly a business issue. The electrical corporation is anxious to sell energy in large quantities to the owners of big buildings. The causes that prevent them are: (a) The present rates for electricity are such as to encourage the operation of private power plants; (b) the use of exhaust steam for heating purposes is a substantial aid to the economical operation of power-plant machinery; (c) the need for a supply of high-pressure steam for industrial purposes, irrespective of the operation of power-plant machinery, is a condition that almost invariably justifies the power plant; (d) the inability of a corporation to guarantee even approximately the future costs of electric service; (e) in existing buildings the power-plant machinery is already installed.

There are, of course, a number of minor considerations in favor of and against the purchase of electric current, but that the operation of independent power plants still remains an economic factor is due chiefly to these conditions. It is not necessary that all these objections to central service be eliminated to render obsolete the private power plant, and it is on this account that the operating engineer should give earnest attention to improvements and to new methods by which he may provide better service and secure a higher degree of economy than is now attained by the private plant.

Effect of Economic Changes

As a striking illustration of the effect of economic changes that are taking place in New York City, a recent study of the operating statistics of a building erected 17 years ago, in which an electric power plant is still in operation, shows that the consumption of electricity had decreased from 200,000 to 140,000 kw.-hr. per annum and the rates at which this current could be purchased had been lowered from 7 to 4¼c. per kw.-hr. This marked decrease in electrical usages was due entirely to the substitution of tungsten lamps for the more inefficient carbon lamps and was not affected by any change whatsoever in the occupancy of the building. It must not be assumed that such reductions always justify the shutdown of power-plant machinery, but the facts must be given serious consideration as an index to the direction in which favorable developments to the central station are approaching.

Another contributory cause to the discontinuation of power plants is the wasteful conditions as regards steam, fuel, electric service and water in and around the machinery spaces in many buildings. Even at the existing rates charged for electricity, many a large power plant is susceptible of successful attack by the public service, solely on account of the excessive losses and wastes in operation. Generally speaking, however, these defective conditions are being corrected as the personnel of the profession improves and as operating economics become better known through the technical press, and in the more modern buildings a high degree of operating economy is secured.

Engineers Desire Flat Rates

With no wish to be unjust to the engineers, the only effort they have so far made against the encroachments of the central station appears to be an outcry against the application of discriminatory rates to secure the business of large power plants. This complaint has now been formulated into a demand for a flat rate for electric energy, irrespective of the quantity used, the character of the load and the time and duration of usage. If such a rate is ever established by law, the private power plants will be secure, but the operating engineers will have done

something which, at the present time, appears impossible to accomplish. Frankly, all this agitation for a lower rate for the small consumer is to conceal the anxiety of the operating engineer to have the wholesale rates raised. It is more like an appeal for mercy than a sound business plea. It would be better if they devoted themselves to the real problem, which is to provide better service at less cost than can be supplied by the central station.

Analysis of the trend of events indicates the eventual monopoly of the business of supplying electric energy by the central station. Lower rates are inevitable. Improvements in machinery, more economical methods in electric lighting and power utilization, substitution of new processes to replace steam heating, will all combine to restrict the field of the independent power plant. At the present time, however, under the prevailing rates and with existing apparatus, the power plant can provide equal service at less cost than the central station. If the operating engineers would study the problem with the same earnestness as the central station interests, its obsolescence may be postponed for a long period of years.

Perhaps a solution may lie in the separation of real-estate ownership from the business of operating machinery. As a matter of business procedure, real-estate owners should not undertake the operation of complex power plants, as a part of building management. The work ought to be done on a contracted basis, as in the case of elevator maintenance, and furthermore, the designing and installing of engine- and boiler-room equipment should be intrusted to the concern that is to operate the machinery. Under existing methods the designing engineer, the contractor who installs the equipment and the operating engineer who bears the heaviest burden represent divergent interests, a condition which can be easily eliminated by having the three functions under one organization.

If independent capital would organize concerns to design power plants for economical operation, to install the equipment in buildings, and to continue private power plants in operation, there is a vast field for remunerative business. The operating engineers themselves are incapable of accomplishing this. It must be done by independent capital. The engineers can undertake the operating duties only. The executive duties of the organization must be conducted by trained business minds. The benefits to be derived by the operating engineer will be in the increased opportunities of employment afforded by the expansion of the field of the private power plant. It is only by coöperation among engineers, combined with an earnest study of the subject, that a monopoly by central-station service can be postponed.

Analysis of Boiler Explosion at West River, N. B.

SYNOPSIS—A 66-in. horizontal tubular boiler with a longitudinal lap joint, double-riveted, working under a factor of safety of 6.75 and carrying but 80 lb. pressure, exploded, killing three and injuring two. The initial rupture was close to the lap of the longitudinal seam.

[The following relates to a boiler that exploded Mar. 17, 1915. The article is a complete analysis of the boiler and the circumstances of the explosion and does not purport to be of news value, but to show what an account of a boiler explosion should contain to be desirably intelligible. Of course, in reports that are intended for news purposes chiefly, such thorough itemization is not possible owing to lack of time. We believe, however, that those readers who favor or may favor us with accounts of boiler explosions will receive valuable suggestions and ideas from this article—Editor.]

A horizontal return-tubular boiler exploded, killing two employees outright, a third dying shortly after of injuries sustained, and two others were injured. Views of the end course are shown in Fig. 1.

The explosion occurred a few minutes after the engines were stopped for the day. The boiler house and engine room were totally wrecked as well as the part of the sawmill adjoining. The boiler was set at the right side of a Robb-Mumford boiler and both were connected together and fitted with separate extension furnaces (dutch ovens) to burn sawdust. The other boiler was damaged by the force of the explosion so much as to be unfit for further use. Both were insured for 85 lb. pressure and the safety valves set to blow freely at 80 lb. There is sufficient evidence to prove that the safety valves were blowing freely at the time of the explosion.

The boiler was 66 in. diameter with a shell 18 ft. long made in three courses of one plate each. The longitudinal joints are lap, double-riveted, and the circular joints single-riveted. The front end extends past the front head to form a smokebox. There is no dome. There were eighty 3½-in. tubes, 16 ft. long, beaded at both ends. The heating surface of the shell was 139 sq.ft.; tubes 1,094 sq.ft.; total heating surface, 1,232 sq.ft. The commercial horsepower rating at 12 sq.ft. is 102.7.

The initial rupture occurred close to the lap of the longitudinal seam. In some places it was clear of the rivet holes and in others just at the edge.

The inspector determined the safe working pressure of the shell as follows: $\frac{60{,}000 \times 0.68 \times 0.375}{33 \times 5} =$ 93 lb. The thickness of the plate is ⅜ in. as measured at the uncalked edge inside of the large, or outside, course, and the factor of safety of 5 is one acknowledged by insurance companies and other authorities as being adequate. The British Board of Trade rules, using the actual tensile strength, thickness of plate and the factor of safety for holes punched before bending and reamed fair, lap double-riveted joints, allow a safe working pressure of $\frac{62{,}900 \times 0.682926 \times 0.390 \times 2}{66 \times 5.2} =$ 97.5 lb., which is 4.5 lb. more than that arrived at by the inspector.

The premises were visited and all parts of the boiler closely examined. The plates were free of surface defects on both sides; no mill stamps of any kind could be found. The boiler was built by a reputable shop, about

1895. It was in use from three to six months a year, ten hours daily, between seven and ten years. A sample of plate was secured close to the initial rupture, fully analyzed physically and chemically and the results are shown in the table. The tensile strength is high, being 62,900 lb., also the elastic limit of 57 per cent. is high. These are the only good physical qualities. The elongation is only 17.92 per cent., but should be 30 per cent. or more. The reduction of area at the point of fracture is only 43.83 per cent., but should not be less than 50 per cent. The bending tests are also very bad. The first indications of fracture occurred when the test piece was bent to a radius $\frac{3}{16}$ in. and to an angle of 170 deg. When bent flat on itself, the fracture was almost complete. The fiber of the material indicated extreme brittleness. The quench bending test indicated an almost complete fracture at an angle of 29 deg. and a radius of $\frac{5}{16}$ in., the fracture being similar to that of cast iron. It is therefore evident that the material lacked that rubber-like quality that is necessary for boilers. The percentage of sulphur was 0.063. This should not exceed 0.035 per cent. according to high authorities and is the quantity that the insurance companies specify as not to be exceeded. Sulphur produces brittleness when the material is heated.

PHYSICAL PROPERTIES

Sample From	Width, In.	Thickness, In.	Area, Sq.In.	Tensile Strength Lb.	Elastic Limit, Lb.	Elastic Limit to Tensile Strength Per Cent.	Elongation in Eight Inches Per Cent.†	Reduction of Area at Fracture Per Cent.
West River..	1.5	0.390	0.585	62,900	38,570	56.50	17.92	43.83
West River..	1.5	0.344	0.0924	68,250	39,610	58.10	34.00	57.10
Aylmer.....	1.5	0.343	0.0924	59,730	33,870	56.70	40.00	60.06
Accepted sample....	1.5	0.343	0.0924	65,420	34,730	52.20	33.00	65.00
Midland.....	1.5	0.290	0.435	51,060	28,140	50.05	12.20	22.80
Our specifications....	1.5	*		55,000 to 62,000	27,500 to 31,000	50.00	25.00	50.00
Average eighteen railroads...	1.5	*		53,333 to 63,000	26,666 to 31,500	50.00	22.55	50.00

* Thickness of plate in inches. † Test pieces with a machined circular section could only be made 1 in. long. The results are to be used comparatively only with similar ones.

CHEMICAL PROPERTIES

Sample From	Carbon	Manganese	Sulphur	Phosphorus	Silicon	Arsenic	Remarks
West River..	0.21	0.60	0.025	0.043	0.042	None	Sample close to rupture.
West River..	0.25	0.52	0.063	0.052	0.066	None	Break of physical test.
Aylmer.....	0.10	0.55	0.045	0.065	0.024	Not det.	
Accepted sample....	0.27	0.57	0.038	0.006	0.072	Not det.	
Midland.....	0.07	0.02	0.025	0.248	0.065	Not det.	
Clamp B&W	0.157	0.504	0.046	0.059	0.018	Not det.	At edge fracture middle of sample.
Clamp B&W	0.228			0.059			
Westville N.S.....	0.160	0.64	0.047	0.058			
Our specifications.....	0.15-.25	0.45	0.035	0.040	0.030		
Average 18 railroads..	14.3-0.25	0.4656	0.0347	0.0331	0.0305		

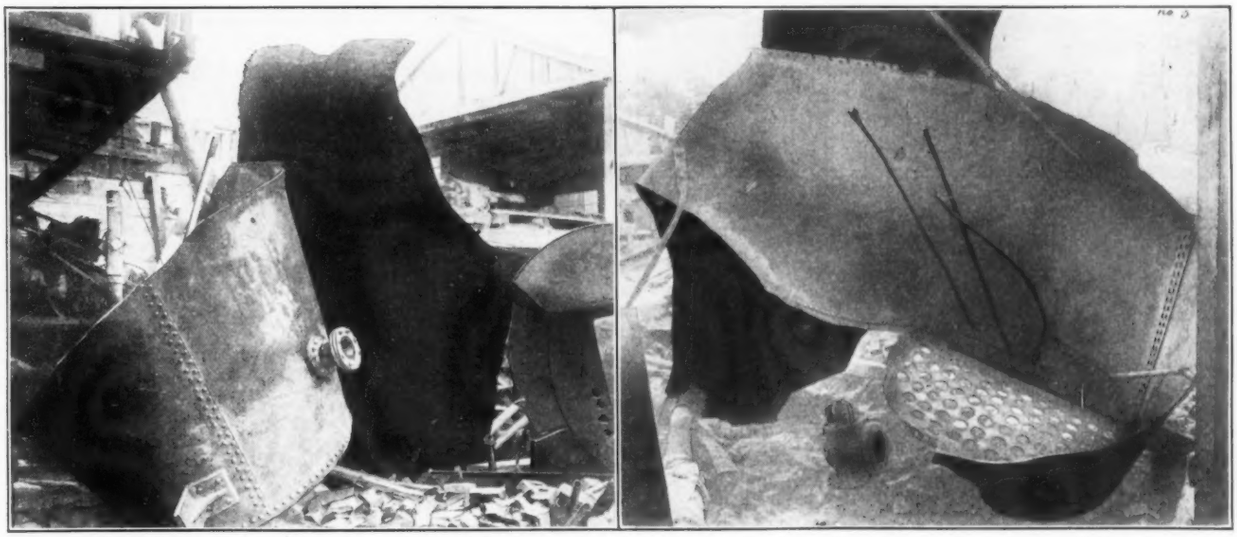


FIG. 1. OUTSIDE AND INSIDE VIEWS OF THE REAR COURSE; THE SHEETS RIPPED LIKE PAPER

This is commonly known as "red short." It makes the material exceedingly brittle at a red heat. Its effects are in general most marked at a dull-red heat. Phosphorus in boiler plate should not exceed 0.040 per cent. In the exploded boiler it was 0.052 per cent. Phosphorus produces "cold short"—that is, it makes the material brittle when cold. It increases the tensile strength in low-carbon steel, but reduces its ductility. The percentage of silicon was 0.042 to 0.066, but should not have exceeded 0.03 per cent. It makes the material hard and brittle. Manganese has a tendency to neutralize it when the percentage is as low as the specifications call for.

It is therefore evident that the brittleness of this material was due to its containing too much sulphur, phosphorus and silicon. The accompanying tabulated tests of material are from samples taken from boilers that have exploded, in which the material was accepted as satisfactory; the insurance-company specifications are given, also the average of eighteen railroad specifications. The Midland sample is from an exploded iron boiler. There were no stamps on the material. The bending tests were very unsatisfactory. All the boilers except the Midland were to be considered safe risks when the safe working pressure was determined from the dimensions to be obtained from the boiler. In these calculations the tensile strength can often be obtained from the stamps on the plate, but the actual chemical properties can only be assumed to be correct for boiler construction. Otherwise it would require samples of plate to be cut from each boiler to be tested. This is a commercial impossibility. It is this fact of uncertainty of the quality of the material that will continue to cause what are apparently mysterious explosions.

After the explosion the plate in which the initial rupture occurred was examined and found to be cracked in one place for 18 in. through the full thickness of the plate, between the rivet holes in the outer row of rivets in double shear. Similar cracks were found

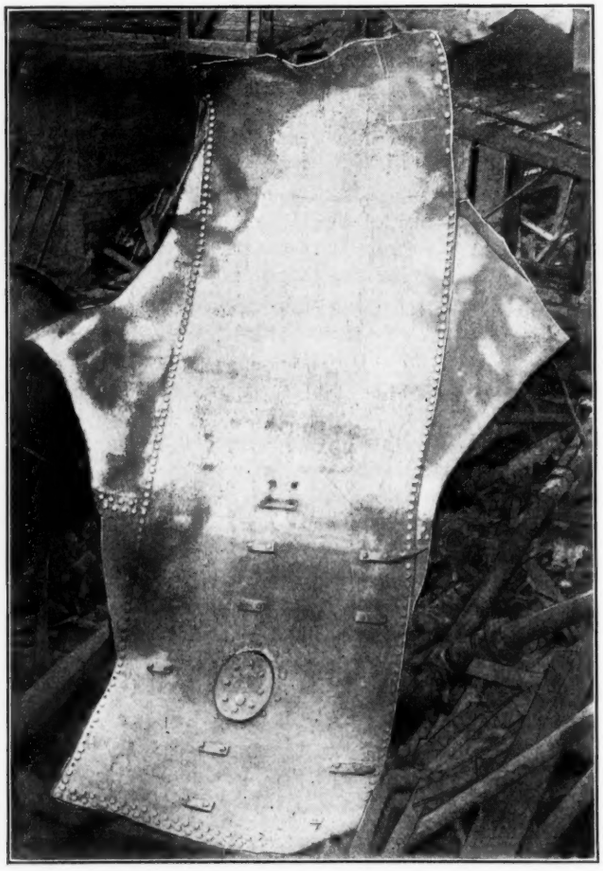


FIG. 2. SHEET FROM CENTER COURSE; NOTE ALL STAYS BROKEN

diagonally between two of the holes in this length and several cracks from other holes up to 1½ in. long. The silicon was low, and probably its effect was neutralized by the high percentage of manganese. There was no evidence of leakage at the calking edge of the strap or at any of the rivets. This boiler was generally operated at a factor of safety of 6.75. This is probably why there was no evidence of leakage. The boiler was only five years old and operated alternately week about with a similar one, so that it had really only been 2½ years in actual operation. The load carried was very small, and the boiler had had the best of care. This was proved by the interior and exterior surfaces of the plate, which were in excellent condition. All stays except one broke at the first rivet hole in the palm. The net area of metal at that hole is only 60 per cent. of the body of the stay. Fig. 2 shows the sheet from the center course.

From Professor Thurston's tabulations the energy to be developed at 5.3 lb. gage pressure per pound of water is 145 ft.-lb., and in one pound of vapor 16,872.9 ft.-lb.; at 85.3 lb. gage, one pound of water equals 6,885.2 ft.-lb. and one pound of steam 99,787.6 ft.-lb. Observe that the energy in the water has increased 47.158 times and only 5.914 times for one pound of steam. This shows at a glance why an explosion due to shortage of water does little damage.

If we assume the water line to have been 18 in. from the top of the shell in the West River boiler and 85 lb. gage, there would be 19.824 lb. of steam and 11,794 lb. of water. The total energy for the steam would be 19.824 × 9,987.6 = 1,977,790.23 ft.-lb., and for the water, 11,794 × 6,885.2 = 81,204,048.8 ft.-lb., or a total of 83,181,839 ft.-lb., or the weight of 460 locomotives lifted one foot high in one minute. It has not yet been definitely determined how many foot-pounds are consumed in destroying the boiler and lost in the condensation of steam. If we assume that 60 per cent. is lost for both there is left 40 per cent. to throw the boiler. If this quantity of energy were utilized to shoot upward a consolidated weight equal to the boiler, this weight would attain a height of 2,603 ft. The initial velocity would be 409 ft. per sec. and would require 12.7 sec. to reach the full height.

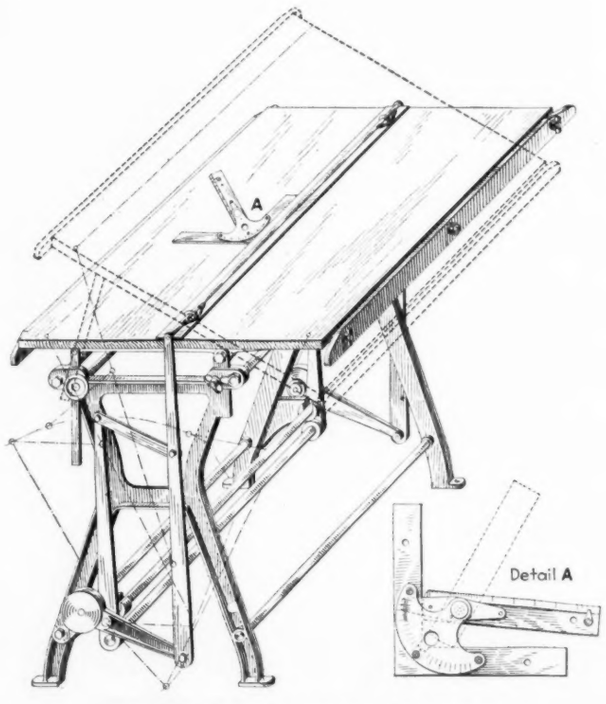
The mill where the accident occurred is situated at the extreme northwest end of the Bay of Fundy, which locality appears to be subjected to almost impenetrable fogs, therefore the photographs are not as clear as one would desire.

New Tilting Drafting Table for the Engineer

Modern-day practice demands that engineers be more or less proficient in making drawings. A convenient drafting table that will assist in such work is illustrated herewith.

This tilting drafting table is adjustable for height by clamps from 35 to 38 in. and tilts from the horizontal to 30 deg. The board holder consists of two castings mounted on a rockshaft, with a wooden front and back piece between which the drawing board is clamped by thumb screws.

The application of the swinging blade enables the rapid use of a long horizontal ruler. This works independently of the conditions of the board as to straight edges or flat surfaces. The ruling edge is carried at each end by a stiff swing that is nearly balanced. The swing



KELSEY TILTING DRAFTING TABLE

is hung from a rockshaft and so adjusted that a slight lift raises the rule a certain distance above the drawing board, where it remains until wanted.

The draftsman's universal square and protractor A is shown at the right of the drawing board. It provides for a large variety of work. The protractor graduation is on the under side of the transparent plate that supports the bushing for the center pin of the tongue. The latter carries a white celluloid arm that passes under the plate and forms a vivid background for the graduation of the plate, which reads to $^1/_6$ of a degree.

This outfit is manufactured by D. J. Kelsey, 51 Elm St., New Haven, Conn.

Liquid Manometers for Light Pressures

By R. S. Bayard

An elementary analysis of the principle involved in the liquid manometer, or U-tube, for measuring low pressures of gases, such as chimney and furnace draft and the effect of unequal tube diameters may be of interest, particularly the question as to whether it makes any difference in the accuracy or the method of reading the instrument if the two glass tubes forming the U are of the same diameter, or "bore." In experimental work it often happens that two commercial glass tubes are not of the same internal diameter, especially if bought at different times, as when replacing one tube after breakage. The effect of this difference is that the movement of liquid will be greater on one side than on the other, and this causes uncertainty in the mind of the observer, and it is surprising how often this question is raised.

If the two tubes are of the same diameter, the downward movement on one side must be exactly equaled by the upward movement on the other side. In Fig. 1 this is shown by a 1½-in. displacement downward at A and a 1½-in. increase of depth at B, making a total "reading" of 3 in. of water, this being equal to the pressure measured.

The area of a ½-in. bore is 0.196 sq.in., and so the volume of the water supported by the gas is $3 \times 0.196 = 0.588$ cu.in. The weight of a cubic foot of water being taken at 62.3 lb., the weight of a cubic inch will be 0.03606 lb., and the weight of the column supported will be $0.588 \times 0.03606 = 0.02120$ lb. This weight being supported on an area of 0.196 sq.in., the pressure per square inch will be $P = 0.0212 \div 0.196 = 0.10818$ lb. per sq.in.

In this calculation the area of the tube enters into the problem twice—once as a multiplier to get the water volume and once as a divisor to get the pressure per unit of area, or per square inch. Thus the area of the tube cancels out in the calculation of the pressure and the net result is simply that the pressure per square inch is the product of the height of water column supported in inches, by weight of one cubic inch of water, or $P = 3 \times 0.03606 = 0.10818$ lb. per sq.in., the same as already found.

The area, or bore, of the tubes therefore has no effect upon the calculation of pressure when both tubes are of the same diameter, but what is the effect when the tube areas are unequal?

Referring to Fig. 2, tube A is ½-in. and the open tube B is but ⅜-in. bore. As before, let the total column of water supported by the gas pressure be 3 in. The relative downward and upward movements may be obtained by calculation, basing the problem, as before, on the fact that the volume forced out of A must be added to B. If, then, tube A is ½-in. bore and its area 0.196 sq.in. and tube B is ⅜-in. bore and its area 0.11 sq.in., then, if x is the depression in tube A, the volume displaced downward is $0.196x$ cu.in. Also, as we have assumed the total column to be 3 in. long, as in the first problem, the sum of the depression in A and rise in B must be 3 in., so rise in B must be $3 - x$ and volume added to B must be $0.11 (3 - x)$ cu.in. But the volume lost by A must equal the volume gained by B, so $0.196x = 0.11 (3 - x)$, or $0.196x = 0.33 - 0.11x$; so $0.306x = 0.33$ and $x = 1.078$ in., which is the depression in A. The rise in B must be, as stated, $3 - x = 3 - 1.078 = 1.92$ in.

Thus the water-level movements are unequal, the depression in A being 1.078 in. and the rise in B 1.922 in., the latter being almost double the former.

Now the pressure represented by the gage may again be calculated by first figuring the weight of the column

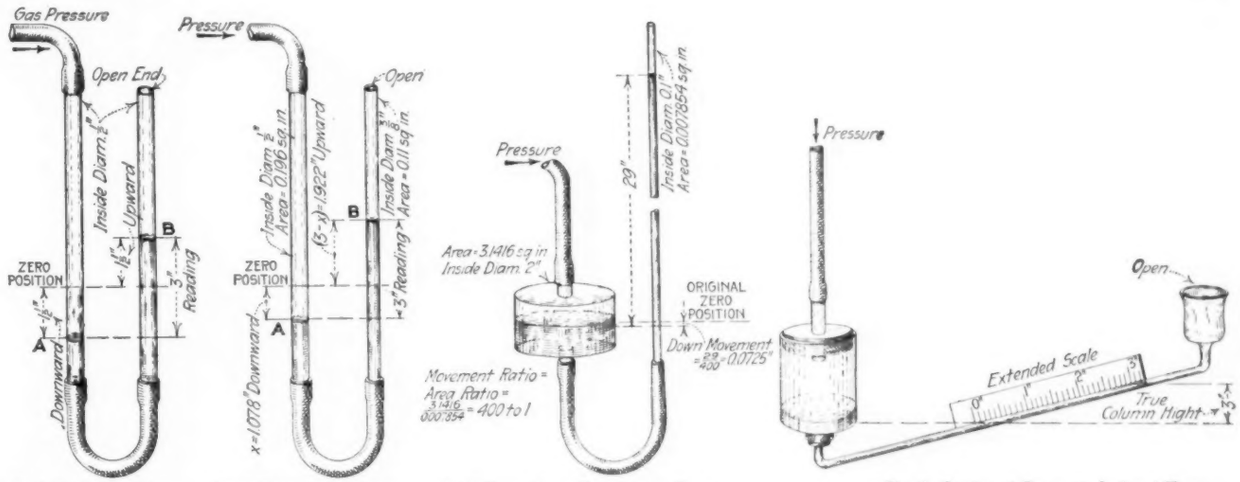


Fig. 1. Tube Diameters Equal

Fig. 2. Tube Diameters Unequal

Fig. 3. Reservoir, or Barometer Type. Practically One Column Reading Only

Fig. 4. Combined Reservoir, Inclined Type

VARIOUS PROPORTIONS AND FORMS OF DRAFT GAGES COMPARED

of water. The area of tube *B*, which is now holding the water column, is 0.11 sq.in. and the upstanding water column is, as before, 3 in.; so the volume is $0.11 \times 3 = 0.33$ cu.in. and the weight of this column is, $0.33 \times 0.03606 = 0.0118998$ lb., and the weight per unit of area, or pressure per sq.in., is $0.0118998 \div 0.11 = 0.10818$ lb. per sq.in., as in the previous problem.

It makes no difference therefore in the result whether the two tubes are of large or small bore, nor does it affect the result if the bore of one tube is greater or less than the other. The only controlling factor is the height of the column, and the pressure measured is always the product of the height of the column by the weight of unit volume of the liquid used. If the height is in inches, the unit weight must be in pounds per cubic inch and the answer will be in pounds per square inch. If the height is in feet, the unit weight should be in pounds per cubic foot and the answer in this case will be in pounds per square foot.

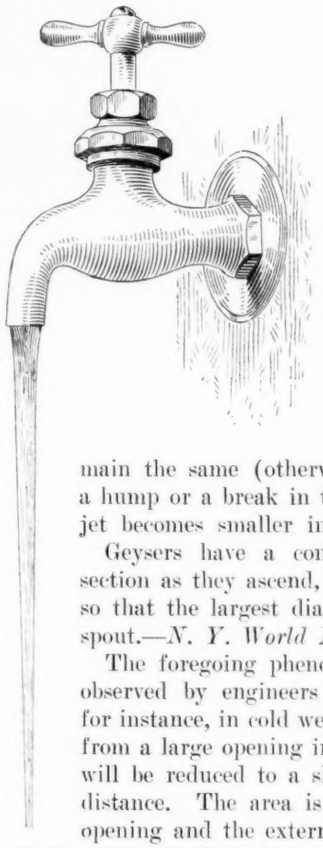
The application of the foregoing leads to a practical simplification of the manometer gage. It was observed that the liquid movement in the larger side of the U was less than that in the smaller one, but that the total height of liquid supported will always be the same for the same pressure and liquid used. It is quite practical to increase the diameter of the pressure side of the U to such an extent that the most of the liquid travel will be in the smaller leg—in fact, so that the movement of the liquid level in the large leg will be negligible. This makes it convenient to arrange the "zero point" at the liquid level of the large-diameter leg and have the entire movement of the column, to all practical purposes, confined to the smaller-diameter leg, and instead of measuring from two moving liquid levels, it is necessary only to measure from the fixed zero point to the height of column in the smaller leg. Of course there is a small error due to movement of level from zero in the large-diameter leg, but this may be made so little that it is negligible, so that the instrument needs to be observed only at one place—the height of the liquid column in the small tube. Many commercial forms of draft gages and some cheap barometers work on this principle. Fig. 3 shows such an instrument, the total reading being 29 in., while the corresponding depression of the "zero" side is only 0.0725 in.

In some cases the draft gage is made on a slant so that the scale may be much extended for close reading. Here the true column of liquid is of course the vertical height as before, but the scale may be laid out on the diagonal, or slant, so as to obtain much larger-scale divisions for a given vertical movement.

This is shown in Fig. 4, it being understood that the vertical dimension of 3 in. is the true liquid column height representing the pressure, just as in the previous case, but that the diagonal scale is laid off in large divisions so that the scale will read 3 in., even though the diagonal distance may be three times as great in reality. This makes it possible to read very small movements of the liquid column with accuracy. To be accurate, the slant of the tube must be exactly that for which it was calibrated and the instrument set level, as the movement will vary with the slant. Disregarding either introduces a grave error, and the instrument should be carefully leveled when set and occasionally checked up with a level for accurate work or its reading will be of little value.

Why a Stream of Falling Water Gets Smaller

Water flowing from a faucet gets smaller the further the stream falls. A stream of water 2 ft. in diameter diminishes to a diameter of only 2 in. before it has dropped very far. Where then does all the water go to?



The explanation lies in the greater velocity of the water as it falls. A pipe of a certain size will transmit a number of gallons a minute proportional to the speed of flow. Water coming from a faucet starts with a relatively low velocity, and therefore the stream has a wide area of cross-section, but as the velocity increases on falling and the number of gallons passing any given point per second must remain the same (otherwise there would be either a hump or a break in the stream) the size of the jet becomes smaller in proportion to the speed.

Geysers have a continually increasing cross-section as they ascend, and the water goes slower so that the largest diameter is at the top of the spout.—*N. Y. World Magazine.*

The foregoing phenomenon may frequently be observed by engineers in handling cylinder oil, for instance, in cold weather. Even when flowing from a large opening in a barrel the stream of oil will be reduced to a slender "thread" in a short distance. The area is contracted just below the opening and the external pressure being equal in all directions, its form becomes circular and remains so unless the side pressure becomes unbalanced or the velocity becomes so great as to cause it to separate into a fine spray as in the case of water falling over a precipice.

Duty of Steam Pumps

Coal per Hp.-Hr.	Duty	Coal per Hp.-Hr.	Duty	Coal per Hp.-Hr.	Duty
4.950	40	2.955	67	2.106	94
4.829	41	2.911	68	2.084	95
4.714	42	2.869	69	2.062	96
4.604	43	2.828	70	2.041	97
4.500	44	2.788	71	2.020	98
4.400	45	2.750	72	2.000	99
4.304	46	2.712	73	1.980	100
4.212	47	2.675	74	1.960	101
4.125	48	2.640	75	1.941	102
4.040	49	2.605	76	1.922	103
3.960	50	2.571	77	1.903	104
3.882	51	2.538	78	1.885	105
3.807	52	2.506	79	1.867	106
3.735	53	2.475	80	1.850	107
3.666	54	2.444	81	1.833	108
3.600	55	2.419	82	1.816	109
3.535	56	2.385	83	1.800	110
3.473	57	2.357	84	1.783	111
3.413	58	2.329	85	1.767	112
3.355	59	2.302	86	1.752	113
3.300	60	2.275	87	1.736	114
3.245	61	2.250	88	1.721	115
3.195	62	2.224	89	1.706	116
3.142	63	2.200	90	1.692	117
3.093	64	2.175	91	1.677	118
3.046	65	2.152	92	1.633	119
3.000	66	2.129	93	.....	...

Cross-Compound Engines can be started without prying on the flywheel by admitting steam to the low-pressure piston through the bypass valve on the receiver, if the high-pressure crank is on the center.

Editorials

Neglect of Printed Directions

It seems to be human nature to neglect to follow or even read printed directions that come with supplies or equipment. Most engineers do not follow directions when they put in a new valve, clean out scale with a mechanical cleaner, blow soot or apply a lubricant. When they pack a valve, they seldom read the directions on the box first. Few have read the direction on a box of packing in a long time, if ever. It is the exception rather than the rule to apply metal lacing in accordance with the instructions of the manufacturer, who has had more experience with his own lacing than has anyone else.

These are all small things, and that is why we are prone to believe that we know all about them without doing any studying. We naturally hate to read directions when they pertain to simple things, for the same reason that we dislike being told how to eat and drink. We much prefer to follow our own desires and tastes.

Also, after reading directions once on a given subject, we conclude that all directions are alike on all similar subjects and we unpack the object hurriedly, throw the directions and box away, and put it on.

Very often some of these things go wrong just because they were done wrong in the first place. The manufacturer is not to blame, exactly, nor is the article itself. Perhaps we can blame haste and over-self-confidence. Let us follow directions unless we are dead sure we know a better way.

Writing Clear Reports

The importance of straightforward reports should be self-evident, yet they are the exception rather than the rule. One recently examined was an unusually elaborate study of the comparative cost of central-station and local service in an industrial power plant; it was a clean-cut job from the engineering standpoint and indicated that in the case at issue the retention of the existing service rather than the purchase of central-station energy was the desirable economic practice.

This report was well handled as a piece of detail work, and no fault has been discovered with its technical side. One of the best things about it is the evidence of thoroughness. So far as there has been time to analyze it, the data look consistent, the computations appear accurate, and the conclusion seems reasonable.

The trouble is that when one endeavors to study the statement he finds himself led all over the field and jumped from one place to another without logical progress. The report opens, and very properly, with a recital of its object. A summary of results then appears, followed by a brief discussion of these results and the conclusion that the substitution of central-station service is inadvisable. This is all to the point except that the introduction of a discussion of results between the summary and the conclusion throws the plant owner's mind off the track and leads him into collateral lines of thought when his attention should be focused upon the natural outcome of the investigation.

Continuing, the report outlines the method of investigation followed, interjects a paragraph describing the installation as a whole and then proceeds briefly to relate the existing power requirements. Before these are fully considered, a more elaborate description of the plant appears, after which is given the present schedule of operation, touching upon the differences between winter and summer practice in handling the boilers. A section then takes up the labor requirements of the installation. Then comes a review of the changes in equipment layout that would be effected if power should be purchased, and there follows an estimate of various costs entailed by the proposed change. Without continuing a catalog of the contents, suffice it to say that, as a whole, the report consists of a large mass of material that needs sifting and classification before it can be rapidly and appreciatively studied. The engineers who prepared it evidently included all the data bearing upon their problem, but they failed to separate the facts sufficiently in presenting them, mixing pages of computation with pages of discussion and producing on the whole a rather incoherent solution of their problem.

Literary grace is not the object of such documents; but if the engineer expects to have his suggestions read by his superior, and especially one not a technical man, he will avoid the discursiveness that so badly encumbers the report taken as a text for these remarks. In placing the conclusion at the front the engineer serves the time and interests of the busy reader, but care should also be taken to place the bulk of incidental discussion and data, alternative calculations, etc., outside the main argument. Few executives have time to follow a rambling assembly of data and comment in checking over recommendations of their subordinates, and the report that tells the story in succinct form, with an appendix, if necessary, containing the side issues and instrument readings, calibration data and other incidental matter, wins the consideration it deserves.

Studying Old Estimates

Few better rainy-day jobs can be found by an engineer whose plant is in apple-pie order than to take some old estimates from the file and endeavor to check their accuracy. If an engineer is on good terms with the accounting department of the company for which he works (and something must be wrong if he isn't), he can put in a very profitable hour or two in this way in some plants, and the advantage will not be all on his side either. It is well for the men in both departments to get something of one another's viewpoints.

Many engineers would unquestionably be glad to check their estimates against actual costs if the practice of keeping estimates were universal; but too often these are merely roughed out on paper without a copy, under

the pressure of the immediate demand, or else important notations are omitted which are necessary to enable the steps in the estimate to be properly checked later. The time is surely coming when the plant owner will realize the importance of throwing his construction costs open to his engineer as the work is finished in plant extensions, changes, etc., sending a carbon copy of all information bearing upon station costs to the engineer as logically as to his auditor. The engineer has a legitimate interest in the finances of his employer, in so far as they are directly affected by plant costs, whether fixed or operating. Further, it is fitting to suggest the value of at least a measure of interchange of such costs and estimates among engineers whom employers in groups know to be trustworthy about making proper use of comparative data.

Much more can be done than has so far been accomplished along the line of comparing detailed construction costs, and the checking of estimates, including a rigorous pulling to pieces of such figures under the light of experience, can be made very useful if done scientifically. It is not to be expected that a complete check can always be effected against construction costs, for in the actual working out of a job in the plant it frequently happens that the classification of expenses for labor and material follows a different line than was roughed out in the estimate. Certain parts of the work have to be done at the most favorable time, and it is not always possible to foresee just what the conditions will be when making preliminary figures on cost. But in hundreds of cases enough data will be on file in the accounting department after the job is completed to give the engineer many good points in future work with which he may be concerned. The bulk costs of equipment, of course, should be open to easy checking, and the engineer and the accountant can often go a long way together in studying to advantage the detailed costs of installation "before and after taking."

The Private Plant and the Engineer

Commenting in this issue upon the future of the private plant, Mr. McHollan sizes up the situation in a way that merits close study. To the private plant he concedes the present advantage, by virtue of such factors as utilization of the exhaust, investment already made, etc., but warns that the margin of competition with the central station is becoming less, and if the private plant is to continue to hold its own, closer attention must be given to the economies of operation and to business methods.

Believing the problem to be purely a matter of lower rates which present central-station economies are making possible, he censures the operating engineer for having attempted to reduce the rates to small consumers with the hope of automatically raising those to large consumers, and thus rendering his own position more secure. Whether such efforts will accomplish their ultimate object is doubtful. However, they are as justifiable as some of the tactics of the central station. In this connection the author might be reminded that although economies in generation and load conditions may have made it possible to reduce the minimum rates, it is a fact that invariably reductions in maximum rates have been made only after a fight on the part of consumers or other interested parties. While production cost may be a limiting factor, the actual rates are usually determined by what the traffic will bear or, as for large consumers, by the competition of the private plant. If the small consumers were in a position to furnish such competition, their rates would be fixed accordingly.

The "supervision company" idea mentioned by Mr. McHollan has worked out well in a number of cities and will undoubtedly find a still greater field in the future.

One of the most significant points mentioned was that the central station solicitor has back of him an organization of trained specialists in both technical and business matters. The operating engineer, on the other hand, has no such backing, and although he may be able to analyze the technical features, he is seldom able to present his case from a business standpoint, such as will appeal to his employer. Although greatly handicapped in this respect, if he is of the right caliber, he will take steps to overcome these obstacles. The trouble is that too many are prone to regard themselves as objects of pity; they spend their spare time in damning the central station without making any effort to make it impossible for the central station to get hold of their plants.

The bibliography of lubrication has taken on so much load in recent weeks that we fear hot bearings.

Now, after engineers have concluded experiments and determined the most suitable percentage of air space for grates for hard coal of different sizes, the coal men are going to change the sizes. Oh, well! 'twas ever thus.

A contributor to a recent issue said that if owners had to get up on a shaky platform in front of a boiler on a July day and blow tubes, they would appreciate that the conditions are such as to so dishearten a man that he does not care whether the tubes are clean or not. Those of us who have performed on that same platform know he talks sense.

Some members of the American Society of Mechanical Engineers, who returned to New York by boat from the spring meeting in New Orleans, liked the trip so well that they propose holding the next spring meeting aboard a steamer, cruising the Caribbean Sea the while. Habitual truants at such meetings please take notice; you are to be shanghaied!

New York City still worries about its refrigerating safety rules. Massachusetts has likewise worried; the state now has a comprehensive, practicable set of rules, as thoroughly and fairly applicable as the highest engineering "hindsight" and foresight can make them. Municipalities and states now using or contemplating such rules may well consider the advisability of adopting those of Massachusetts, which have the approval of the American Society of Refrigerating Engineers. Refrigerating safety rules are coming. There is no question about it. Would it not be better in every way to start out with standardization of such rules in view instead of having a hundred different bodies all working at cross-purposes, wasting time and money only eventually to standardize such work? Are we to gain nothing by the long and troubled experience in steam-boiler legislation?

Correspondence

Exhaust vs. Live Steam Heating

Replying to Mr. Underwood's letter on page 485 in the issue of Apr. 4, in which he states that with exhaust-steam heat the bottoms of radiators are comparatively cold, I have found this to be true with either exhaust or live steam, and this is only natural. The passage of air around a radiator is generally upward, bringing the coldest air into contact with the bottom of the radiator. The temperature difference being greatest at this point, the condensation is more rapid, but as the air ascends it becomes hotter and takes less heat from the radiator; besides, the bottom of a radiator may be cold because of the accumulation of water. These points apply in most all steam-heating systems regardless of the source of steam supply.

In using exhaust steam there may be some trouble in a poorly arranged system from oil. If there is no separator, the oil may be carried into the radiators, insulating the contact surface so that steam cannot touch the iron. Naturally most will deposit at the bottom.

Mr. Underwood's difficulty in the hospital buildings was probably caused more by insufficient return capacity shown by the moisture in the steam. If the return entered the boilers—1,700 ft. away—the flow would be sluggish unless it was pumped or hurried by some other means. The temperature difference between steam at 85 and 70 lb. is only about 14 deg., and the difference in heat units is only 8, so this difference could not so increase the moisture as to cause the trouble mentioned. Probably the system was water-logged and the returns could not handle it.

I have had as good results heating with exhaust as with live steam. H. K. WILSON.

New Bedford, Mass.

Value of Cylinder Oils

In the issue of Apr. 11 Charles E. Carpenter says, "Viscosity is the great humbug test featured in all specifications. . . . It means absolutely nothing and proves nothing to the consumer so far as the final quality of a cylinder oil is concerned."

This statement will be misleading to the average operating engineer, who has not the opportunity or the inclination to delve into the subject sufficiently to form a satisfactory or correct conclusion, and who, because of the statements of men supposedly competent to know and whose statements are diametrically opposed to one another, is between the devil and the deep sea, and finally makes up his mind that there is no such thing as cylinder lubrication.

It would be much less confusing if Mr. Carpenter had stated his premises, and I am assuming that he is reserving these premises until somebody walks into the trap he has set. Frankly, he should have gone farther and stated that under certain conditions a steam-engine cylinder can be run without any oil whatever.

I well remember when "Second" of a ship in which the main engines never had a drop of cylinder oil during the year I was in her. The "Chief" told me that they had had no oil for two years and would have none while he was in charge. These cylinders ran smoothly and undoubtedly got their lubrication from cylinder condensation.

In another ship which I was in, the orders were to give neither the main engines nor the auxiliaries any cylinder oil except when they "asked for it." They usually asked for it three or four times the first day out and once or twice the second, after which they got little or none until we reached port, being given a liberal dose just before docking. Of course these were vertical engines and after the cylinders became burnished, required very little lubrication.

On the other hand, I have seen a good many engine cylinders badly cut while the engineers were trying to do this same "stunt," the secret being probably in the quality of the steam, as well as in the character of the cast iron in the cylinders—being successful if the metal is dense and hard and a failure if soft, spongy and gritty.

I have known of a number of refrigerating machines in British ships with horizontal compressors running 150 r.p.m., in which the compressor cylinders got no lubricant day after day, except the liquid anhydrous ammonia which was purposely allowed to come over with the gas.

Mr. Carpenter's contention is undoubtedly correct for the reason that practically all engine builders bore out the steam cylinders as smoothly as possible and into this cylinder put a piston that weighs from 50 lb. to 5 tons. The piston is turned usually $\frac{1}{32}$ in. or more smaller than the cylinder, and under these conditions is in contact with the bottom of the cylinder on a narrow longitudinal line, giving in the case of the larger pistons and cylinders a load of hundreds of thousands of pounds per square inch of projected area in contact. This area of contact is undoubtedly increased by distortion of the cylinder under the load and is further increased by some immediate wear and fitting of surfaces until the arc of contact between piston and cylinder is sufficient to prevent abrasion of the metal, after which burnishing takes place, if the metal of the piston and cylinder are "good," and if they are not good abrasion continues until the arc of contact is sufficient to carry the load without abrasion and to allow of burnishing.

Under these conditions true lubrication—that is, the interposition of a film of liquid between the piston and cylinder, thereby substituting liquid friction for metallic friction—is impossible, no known practical liquid being capable of sustaining the excessive load per square inch of area. The result is that the major portion of the weight of the piston and rod is carried on the metal of the cylinder and the only lubrication possible is where some more or less incompressible liquid fills the pores and depressions, thereby preventing the minute projections of one element getting under the skin of the other.

Further than this, the cylinder condensation is washing the surfaces more or less continuously, tending to float the oil on the surface of the condensate, and this, especially in large low-pressure cylinders, often creates a condition where the contact between the piston and cylinder is in running water pushed ahead of the piston and with sufficient depth to prevent the lubricating oil from getting between the surfaces, except possibly as an emulsion.

Add to this condition the fact that most cylinder lubrication is attempted by atomizing a drop of oil and so thoroughly distributing it in the steam supply that it will be carried evenly to all metallic surfaces in contact—which, by the way, is another practical impossibility—and the reason for Mr. Carpenter's statement becomes plain.

Under such conditions the lubricant which would seem to give the best results will be one which lends itself most readily to atomization and a thorough mingling with the steam, and secondly, one which will emulsify or possibly slightly saponify in the condensate, thereby getting in contact with the metallic surfaces, notwithstanding their wet condition, and adhere to those surfaces with the greatest tenacity. These qualities are supposed to exist to a greater degree in animal or vegetable oils than in so-called mineral oils, certain animal oils being used almost wholly for this purpose; and it is only fair to assume that inasmuch as Mr. Carpenter's company has recently put upon the market a cylinder lubricant in which an animal oil predominates, it is these qualities which he has in mind, and this would seem to be further indicated by the fact that the animal oils in question lose viscosity rapidly above 300 deg. F.

This argument is quite logical when applied to steam cylinders under the conditions before described, but it does not hold good when applied to many types of valves through which steam is admitted and discharged.

This is true of the flat slide and gridiron valves when placed vertically, and is true in general of the Corliss valves of various types, which run comparatively dry and in which the pressure per square inch of area in contact is within the limits wherein a film of oil can be maintained if the oil has sufficient body at the temperature.

Here is a condition where viscosity counts, particularly with valves having large and extended surfaces, where the steam flows over the valve in a comparatively dry condition and the oil gets in at the top edge and is carried between the valve and its seat by the wiping or "buttering" process. This is a different condition than exists in the cylinder, and it is a common thing in practical operation to have the valves groan when the piston gives no sign of distress.

I have had a large engine with Corliss valves which gave considerable trouble because the valves would groan and even show a slight chatter with the oil which we were using and with which the pistons of this engine ran smoothly. We were using a high-grade oil and after some experimenting got an oil which eliminated the trouble with the valves. Tests of samples of each oil showed practically the same viscosity at 212 deg., but the flash and fire tests were higher in the oil with which the valves operated quietly.

It occurred to me to make a comparative viscosity test at the temperature of the steam, which was 450 deg. F. This developed the fact that none of the standard viscosimeters were equipped for such a test, and it was only after some soliciting that I was successful in having some tests made of the viscosity of the two oils at temperatures of from 212 to 450 deg. F.

The results were somewhat surprising, although they should have been anticipated. The oil that carried the valves smoothly and that had the higher fire and flash test gave the same viscosity as the other from 212 to about 350 deg., after which and up to 450 deg. the first oil increased its viscosity lead very markedly, showing conclusively, in my opinion, that comparative viscosity is indicative, but only if taken at operating temperatures.

From this it would seem that the valves and piston may operate under different local conditions, and to meet these a combination of animal (tallow) and mineral oil of the necessary viscosity is best suited for the purpose and this (a compounded oil) is just what is recommended by most oil dealers and used by a large percentage of successful engineers.

From this it is evident that the discussion of viscosity will work around in a circle, and after we have all the facts we will get back to what has been already demonstrated by practical operation.

It is not enough to say that the viscosimeters of Saybolt, Redwood, Engler and others are neither correct nor in accord, neither is there any further excuse for assuming that comparative viscosities at 212 deg. are necessarily any indication of what they will be at 350, 450, or 550 deg., for there is now an instrument which not only gives comparative and correct results, but with which viscosities can be read instantly and plotted as the temperature increases.

Lubrication by atomization in the steam current is bound to be wasteful, as most of the oil so used goes straight to the exhaust without having done any useful work, and even with an excess of oil so applied it is quite impossible to properly lubricate the upper surface of a horizontal piston, where the packing rings come in contact with the cylinder, particularly in large slow-running engines; and while tallow is the more easily atomized, it has not the staying power of a high-viscosity mineral oil at high temperatures when the conditions are such that the mineral oil can be got into contact with the metal of the cylinders or valves.

I recall, when a locomotive engineer, I was cautioned to use nothing but the best melted tallow in the steam cylinders and valves of the Westinghouse air-brake pumps, because the makers would not guarantee their operation if other than tallow oil was used. The tallow pot was kept on the "boiler butt" so that it was ready to fill the lubricator whenever it became empty, which was always indicated plainly and promptly by the squeaking and groaning of the piston and valves. This lack of staying power, together with the development of acid corrosion, soon caused so much trouble with defective and sticky pumps that the makers objected to the use of tallow except in a minor quantity compounded with a good mineral oil.

Modern power-house equipment, with superheated steam, steam-jacketed cylinders and heads, together with the higher piston speeds, reduces to a minimum cylinder condensation and makes it possible to so design piston and cylinder that the load is less than 25 lb. per sq.in. of projected area, and it is also possible to so bore the

cylinder that a mineral oil will not be floated off the surface by the condensation, thereby substituting liquid friction for metallic friction, this being really what constitutes true lubrication; the proof of this being that cylinders so designed and bored after several years of constant operation show no signs of metallic friction, the severity of which is indicated in the average engine by the burnished appearance of the bottom of the cylinder, which is the result of the projections and depressions in the metal having been ironed out by metallic friction, which has stopped short of abrasion. And this is further shown by the gradual lowering of the piston in the cylinder, which in many engines becomes $\frac{1}{32}$ in. in five or six years' operation.

With a cylinder designed with a definite area of contact and bored as before stated, especially with superheated steam, I have obtained better lubrication with a straight mineral oil applied by the surface "buttering" process than was obtained with atomized animal or compounded oil, with no appreciable cylinder wear whatever after years of operation; and under these conditions I have never known of a difference in lubricating quality observable in operation that was not plainly shown in the viscosity test if the comparative viscosities were taken at the temperature to which they were subjected under working conditions in the cylinder.

Boston, Mass. F. L. FAIRBANKS.

Rhode Island Engineers

In the Apr. 18 issue of *Power*, page 558, you quote me at the license hearing before the Rhode Island Senate as saying that "There was a day when the Rhode Island engineers were among the best in the country."

This is a part of my statement, but I think it would be more just to me if the whole sentence were given. That is, "There was a day when the Rhode Island engineers were among the best in the country; now they are just as competent as ever, but seem to lack the necessary certificate to prove it to some of our manufacturers." This statement was made in connection with Rhode Island plant owners refusing to employ engineers without a license, and there are more of these than engineers who have not followed it up suspect.

Pawtucket, R. I. GEORGE F. WEATON.

Steam-Trap Trouble Cured

I was called to put a steam-heating coil in a small office some time ago, and as things were pretty well cramped up, I was up against the problem of locating the trap. About all the other traps we had were of the bucket type, but here I decided to use the expansion type, and it worked so well that we ordered another to replace an old bucket trap. This second trap worked fine for about a week, and then it stopped. I readjusted it, and it worked another week and again stopped. After doing this three or four times, I took the trap off and found it full of small pieces of rust. The heaters to which the trap was connected were used only in cold weather and this gave them a chance to rust inside; when the steam was turned on, this rust would gradually wash out to the trap. The valve in this kind of a trap doesn't travel far, and the sediment lodged between the valve and its seat, stopping it up.

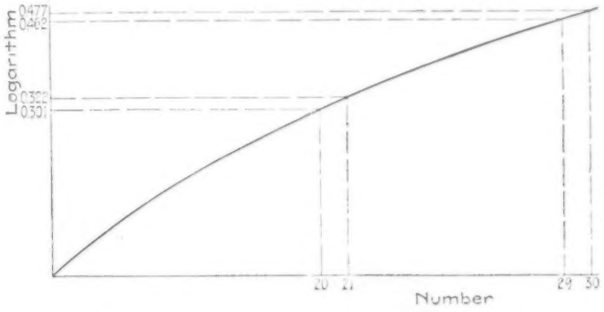
As a remedy a tee was placed in the horizontal pipe leading to the trap, with its side opening looking down, and a short nipple with a cap and pet-cock attached, served as a sediment chamber, so that about all the rust and sediment now collects in this chamber and the trap is working fine.

Others no doubt have had similar trouble, and I'll wager there are a good many traps and other devices of this kind that have been condemned and thrown in the scrap pile for the want of a good strainer or a dirt catcher of some kind. JOSEPH GERBER.

Dansville, N. Y.

Interpolating Logarithms

I wish to call your attention to the article on "Interpolating Logarithms with the Slide Rule," on page 451 of the Mar. 28 issue of *Power*. The writer of this purports to obtain a great accuracy in interpolation, but this is largely illusory, as he is stretching the method of directly proportional interpolation far



RELATION BETWEEN NUMBERS AND THEIR LOGARITHMS

beyond the permissible limit. First, as a general proposition logarithms should not be used for a greater number of significant digits than there are digits in the mantissa of the logarithm; that is, a five-place logarithm table will give numbers accurate to five significant figures, although with these the last figure may be one in error in numbers above 70,000. Secondly the logarithms of numbers between those given in the table are not directly proportional to the differences, but follow the law of the whole table and have progressively smaller differences as the higher number is approached.

This may perhaps be seen more clearly from the curve, for while this is a very much exaggerated case of interpolation the form of curve and principle are the same. Here interpolating for 2.1 by direct proportion, we would get $\frac{.477 - .301}{10} + .301 = .3186$ instead of .322 and for 2.9 $.477 - \frac{.477 - .301}{10} = .4594$ instead of .462.

The true method of interpolation based on the principle of successive differences is rather complicated and may be found in textbooks on practical astronomy.

Engineers, however, have very little use for figures of this class as few measurements or basic data have an accuracy of better than $\frac{1}{10}$ of 1 per cent., and it is foolish and misleading to carry out a figure to several places of decimals because the dividend does not happen to contain the divisor as a prime factor when both divisor and dividend may be uncertain to the extent of several hundreds.

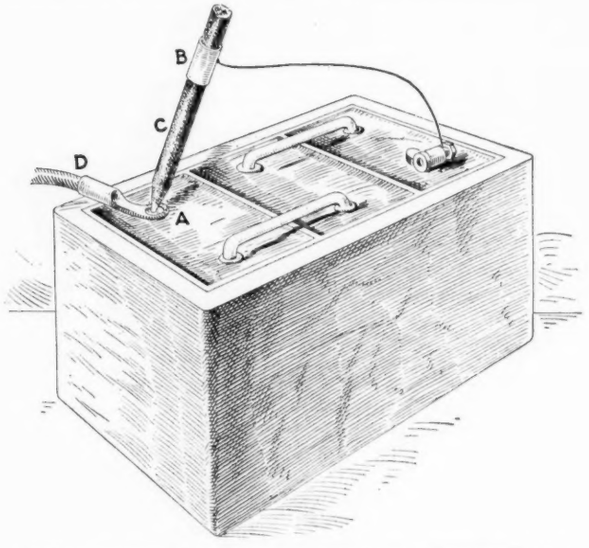
The writer has no wish to decry accuracy in power-plant measurements, but if more trouble were taken to see that coal scales were checked occasionally and weights read properly and less to figuring daily evaporations to three or four places of decimals, the results obtained would more nearly show under just what conditions the power plant is operating. H. D. FISHER.

Newton Highlands, Mass.

Burning Battery Connectors

Mr. Dickerson, in the Apr. 11 issue of *Power,* expressed a desire to learn of an inexpensive way of fastening lead connectors to the binding posts of storage batteries. I have found that the following method works nicely:

Referring to the sketch, *C* is an old carbon from an electric arc lamp which has the tip filed down somewhat to decrease the cross-sectional area. This carbon is connected to one binding post of the battery with a No. 8, or larger, wire. It is a good plan to fasten a piece of sheet brass tightly around the carbon as shown at *B* and solder the wire to it. When the lead connector is to be soldered to the binding post, the surface should be well scraped with a knife so as to expose a clean surface, otherwise the weld will not hold. The carbon is now held against the binding post, as shown in the sketch, and quickly heats up, melting the lead. As soon



CONVENIENT METHOD OF BURNING CONNECTIONS

as the lead begins to melt, the carbon is manipulated like an ordinary soldering iron. This device costs practically nothing to make, and the amount of current it uses is very small. JAY H. SCHMIDT.

Cleveland, Ohio.

Home-Made Pump Speed Regulator

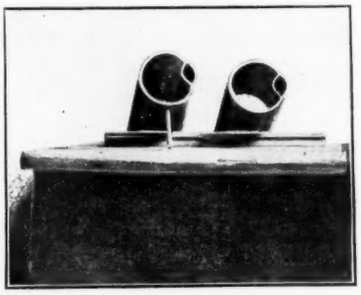
The illustration on page 631, May 2, 1916, of a collection of valves and fittings that look like a steam-calliope attachment to a pump for regulating the speed seems like a long way to nowhere and a failure to get there. It certainly cannot perform the function of an automatic regulator it is said to have replaced.

One good valve located, say, above the lubricator in the main steam pipe, to be used only when it is necessary to shut off all the steam and left "wide open" when the pump is in use, and another—preferably a brass disk valve—conveniently placed for throttling, are all that is necessary and a whole lot cheaper and not unsightly. The regulating valve obviously need not be steam-tight for the service it is to perform.

New York City. J. LEWIS.

Oddly Bagged Boiler Tube

The illustration shows an odd bag in a boiler tube, one in which the tube was bagged both in and out at the same place. The pieces shown were cut from a 3¼-in. No. 1 Stirling tube near the top rear drum, the No. 1 tube in a Stirling boiler being the last tube from the front of the boiler and in the last pass. This tube did not fail, and the bag was found by boiler washers when it was impossible to get the turbine cleaner through the tube. In all probability the tube had been in this condition for some time with the boiler in service.



BOILER TUBE WITH PECULIAR BAG

The bag was about 8 in. long and bulged in to the center of the tube ⅜ in., and out from the center about the same distance. The cause was apparently laminated metal in the tube, as the failure was not at the weld.

Water evidently found its way into the space between the layers of metal forming the defective tube, the pressure being great enough to bag the metal; then the water must have formed steam or expanded on heating to cause the bag inward. After the water entered the space between the layers of metal it apparently could not return to the inside of the tube as fast as its pressure or volume increased, or the opening may have been sealed. When the tube was cut with a hacksaw, the bag was full of water.

This is the second tube failure of this kind that has developed in this plant since it has been in operation.

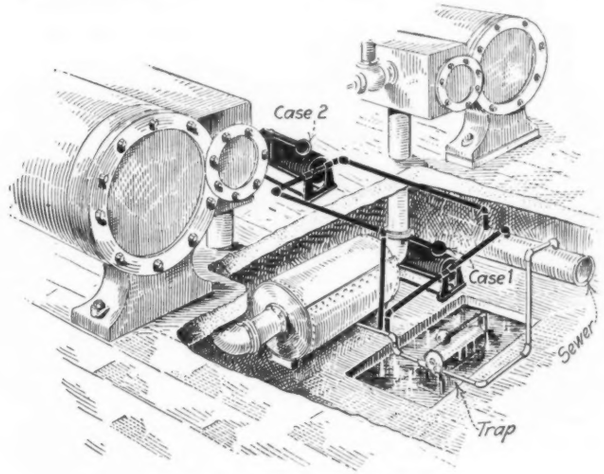
Springfield, Ill. C. A. CRYTSER.

Pit Water Caused Trap Trouble

The story on page 564 in the issue of Apr. 18, by V. R. Hughes, in regard to the failure of a tilt trap to work when partly submerged, suggests the question, Why locate the trap in the pit at all? In fact, the receiver would be drained when the engine is in service just as well if the trap was located up somewhere out of the pit—on the floor alongside of the receiver (case 1) or on the engine-room floor if not unusually high (case 2). The pressure in the receiver in all probability is not less than 25 lb., so that the water in the drain pipe would reach a level at least 50 ft. above the bottom of the receiver. A drip pipe from the bottom of the receiver to the pit would be necessary when the engine was not running and there was no steam pressure in the receiver. This drain valve—operated from the engine deck—would be

opened and closed at the same time and in the same way as the cylinder drains, and therefore no more likely to be forgotten or neglected than the cylinder drain valves.

There seems to be a general notion that steam traps must be placed below the drain connection. This is the chief reason given for locating traps in the unreasonably



CHOICE OF LOCATION FOR TRAP

out-of-the-way places in which they are often found. No "self-respecting" steam trap should be expected to render good service when situated as some of them are. Keeping the trap away from the water is a lot better than a telltale and "forcible instructions" to keep the water away from the trap.

Another point in the story is that this is a case of the wrong type of trap for the given conditions. The inclosed "pot," or "float," type will work even if submerged, although it is not to be understood as the ideal environment.

Quite a proper caption for this letter would seem to be "A Plea for Better Treatment and Working Conditions for the Unfortunate Steam Trap." LEON LEWIS.

New York City.

Getting Along in an Overloaded Power Plant

The power plant of a large institution had two 18-ft. by 60-in. return-tubular boilers that had had their grate area increased from 30 to 36 sq.ft. The load had steadily increased until it became difficult to supply the required steam.

Before recommending an increase in boiler capacity, I determined to see what we could do with old fans, motors, etc., that were about the place. A 36-in. fan was placed alongside the boilers and connected to the ashpits by an iron duct. This was provided with individual wind gates so that the ashpit pressures might be regulated to suit the fuel-bed thickness. An old elevator motor was made to drive this fan by belt.

A damper regulator was installed, with an individual chain to each boiler flue. Also a third chain, carried over a pulley, actuated an electrical contact, automatically starting and stopping the fan motor.

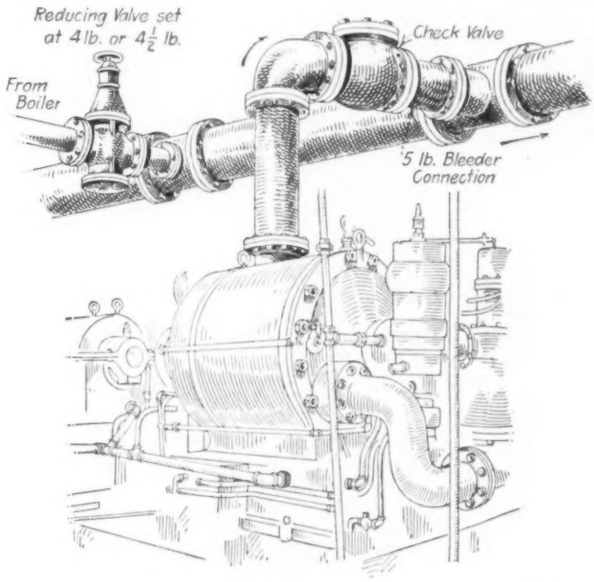
The hot-water supply for the laundry, which turned out 125,000 pieces per week, was dependent upon a live-steam-heated hot-water generator. The exhaust steam went to waste. A small vacuum pump was provided with a cold-water spray and attached to the returns of the generator and the exhaust of the engine piped into the coils. The returns from the mangles and dryers were collected in a tank and reused in the washers. These latter changes have helped the boilers, as they have reduced the demand for steam. EDW. T. BINNS.

Philadelphia, Penn.

Operating Bleeder Turbines

Mr. McGilliway's letter on page 447 in the issue of Mar. 28, under the caption "Operating Bleeder Turbines," brings up an interesting point. Although not operating such turbines, I have had experience with them in suggesting their application and calculating their capacities. The illustration shows what I believe to be a solution of the problem stated.

The reducing valve is set for a lower pressure than that of the bleeder, so that it will not open until the turbine cannot possibly furnish sufficient steam to maintain the pressure for which the valve is set. As in the



EXHAUST CONNECTION FROM BLEEDER TURBINE

case cited, if the bleeder valve on the turbine is set for 5 lb. and the reducing valve for 4 lb., the bleeder turbine will furnish as much steam as it possibly can in order to maintain 5 lb. in the bleeder line. If, however, the requirements are greater than the turbine can furnish, the pressure in the bleeder line will drop below 5 lb., and when it reaches 4 lb. the reducing valve will admit steam to the system until the requirements decrease, when the reducing valve will close; and unless there is a difference of pressure between the turbine and the bleeder valve, there can be no flow. J. BRESLAV.

Hartford, Conn.

In the plant where I am employed bleeder turbines are used to supply a district steam-heating system, and we have no trouble with live steam backing up on a turbine and stopping the flow of steam. We have a flow meter on the bleeder line and also one on the live-steam line, so we can tell what each is doing at all

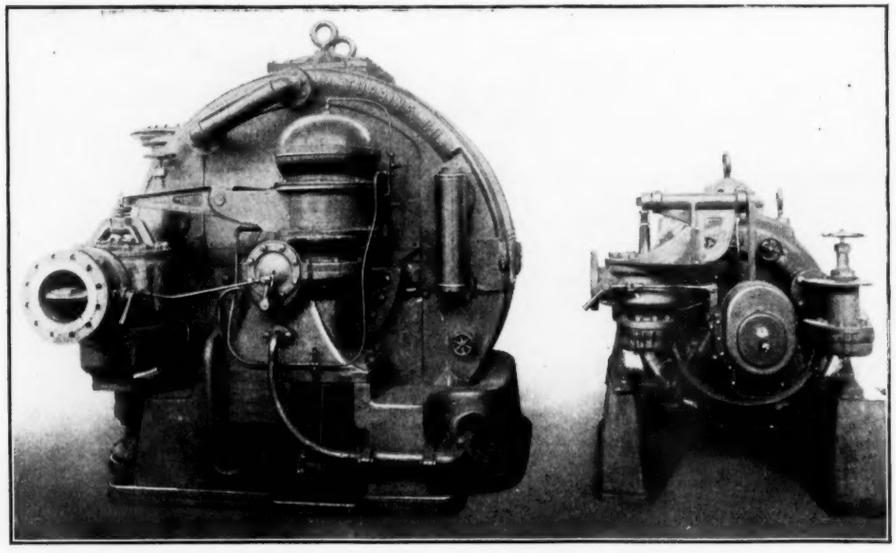
times. It is possible to use so much live steam or set the reducing valve for so high a pressure that there is no flow from the turbine, but as the greater quantity is usually taken from the turbine and only a little live steam is used to make up the deficiency, there is not much chance of obstructing the flow from the turbine.

Just now we are running with the condenser cut out entirely; all the exhaust goes to the heating system, and the turbine is carrying just sufficient load to furnish the required exhaust. The remainder of the load is cared for by the hydro-electric plant with which we are tied in. The load is not enough at all times to supply all the steam required for heating, and live steam is admitted through a reducing valve, but I have never seen the flow meter show less exhaust steam passing on account of the flow of live steam. W. O. PERKINS.

Bristol, Conn.

Six Years' Development in Steam Turbines

An interesting demonstration of the change in turbine design during the last six years is shown by the photographs. The turbine on the left is an example of early practice; that is, the use of a large-diameter wheel operating at a slow speed to obtain a proper relation between the rim speed of the wheel, or the blades, and the steam speed. At that time this was necessary because most of the driven apparatus was operated at slow speeds. The particular turbine shown was designed about 1910 to operate at 1,800 r.p.m. One of them is driving an alternator at that speed at the plant of a lumber company, and another is used for belt connection to a paper machine. This was the first time a turbine was used for the latter service.



BOTH OF THE SAME CAPACITY—THE RESULT OF SIX YEARS' DEVELOPMENT

This type might still be used for the same service, although the advance in gear design would probably warrant the use of the turbine shown on the right. The use of herringbone reduction gears and the increase in the speed of turbine-driven apparatus have made possible the use of higher rotative speeds for the turbine, with a decrease in size and an increase in efficiency.

The turbine on the right is the composite design described in the Mar. 30, 1915, issue of *Power* and is capable of higher powers and greater efficiency than the one on the left.

This same tendency to higher speeds and smaller sizes is doing much to make the turbine the proper drive for main and auxiliary units. J. BRESLAV.

Hartford, Conn.

Recedence of Water Level in Deep Wells

Various methods have been employed to measure the recedence of the water level in deep wells at different rates of flow. Engineers who are confronted with this problem may be interested in a method I used to find the point to which the water level was reduced when pumping 100 gal. per min., so as to determine the depth at which the pump should be placed.

For testing the flow of the well, a single-acting plunger pump was used, submerged to a depth of 160 ft. and operated by the drill rods and beam of a deep-well rig.

A piece of sheet lead 1 ft. long, ½ in. wide, and $\frac{3}{16}$ in. thick, was riveted to a piece of steel $\frac{1}{16}$ in. thick. One end of this weight was attached to a coil of No. 18 rubber-covered fixture wire, and the other end of the coil of wire to one side of a test set, or bell-ringing magneto. The other side of the magneto I grounded to the pipe.

To insulate it from the pipe to prevent a short-circuit, the lead weight was wrapped with tape with the exception of the bottom end, which was left open to complete the circuit when this end came in contact with the water. This weight was raised and lowered between the coupling on the 8-in. casing in which the pump worked and the sides of the outer 10-in. casing, with only $\frac{5}{16}$ in. clearance between them.

The fixture wire was marked every 10 ft. so that the recedence of the water level could be noted at a glance as the weight followed it down and communicated its depth to the surface by the ringing of the bell on the test set.

When the well was at rest, the water level stood at 30 ft. below the ground surface. By running the pump at different speeds for short periods of time and measuring the flow during these periods by means of a weir, the recedence of the water level was plotted to correspond to the pump delivery in gallons per minute.

This performance was continued until the required amount, or 100 gal. per min., was delivered, when the level of the water was found to stand at 97 ft. below the surface of the ground and remain at that point for a period of eight hours while delivering the desired rate of discharge; and it was decided to place the working barrel of the pump at the depth of 120 ft.

Delavan, Wis. L. R. STARK.

Cylinder Lubrication Question*

The discussion regarding the proper quantity of cylinder oil to use for cylinder lubrication has been interesting to operating engineers. The lubrication of extraneous journals, cranks and bearings may be worked out mathematically to a scientific degree of nicety and found reasonably correct. Theorists, presuming a certain thickness of oil film, size of bearing, temperature, specific gravity, revolutions of shaft, etc., sometimes come close to the practical requirements, but where cylinder lubrication is being considered, a cut-and-try method is the only way the engineers have found satisfactory.

James Baudino, page 192 of the Feb. 8 issue, who in 28 years has never seen an engine ruined by giving it too much cylinder oil, may be correct in his theory in so far as the engine itself is concerned, but if he were to follow the intricate course taken by the exhaust steam after leaving the engine he would undoubtedly find that his over-indulgence of oil was destroying, or at least impairing, the efficiency of some other piece of apparatus.

Certain types of engines, owing to constructional differences, require more oil than others, but there is a point in the proper lubrication of all engine cylinders midway between too much and too little that will well repay the engineer for his trouble in finding. When that point is found, it is well to allow a little on the too-much side.

Lack of lubrication means more friction between the cylinder walls and piston rings, thereby reducing the mechanical efficiency of the engine, with the result that it requires more steam for the same work or reduced work for the same steam, both of which eventually reach the coal pile, and in the course of a year or less the effect is noticed in dollars and cents.

Lack of lubrication may mean a scored cylinder, piston rings, piston rod, valves and metallic packing, should they be used, the replacement or repair of which will cost more than the little extra oil accumulated over a considerable number of years.

To discommode an establishment while having a cylinder rebored, new piston rings put in, piston rod turned, etc., resulting from a desire to save a few cents in oil, is poor economy.

Cylinder oil is reasonably cheap, the quantity required is reasonably small, and even should the amount fed be twice that required, it would take a good-sized plant to make the total cost for cylinder lubrication a formidable item.

There is another side to this question that Mr. Baudino lost sight of. All the units in his plant are small simple engines. This type is generally installed where there is a demand for exhaust steam. All the oil being fed to the cylinder will pass out with the exhaust steam, except the little that may pass out in the drips, and as there are few uses to which exhaust steam is put where entrained oil is not undesirable, reason would dictate that no more oil be used than that required to keep the engine operating properly.

Where condensing engines are used, too much oil will interfere with the efficiency of the oil separator should one be on the exhaust line; it will compel more attention to the filtering mediums in hotwells or open heaters if the water is to be used for boiler-feed purposes, otherwise the oil will find its way to the boiler, resulting in laborious cleaning, bagged tubes and sheets.

Condenser tubes will become coated or completely clogged, the oil acting as an insulator, preventing the proper exchange of heat, with the result noticeable in the vacuum causing a reduction of engine efficiency. An instance was where a vacuum pump of a steam turbine exhausting into the same condenser as the main unit used sufficient oil to clog the tubes in a short time, the vacuum dropping from 28 to 21 in.

Testing for the proper quantity of cylinder oil by the cut-and-try method should be a gradual and careful process, ample time being given between each change of quantity to note the results. After making these tests in our plant, the following were the results obtained:

The engines are triple-expansion, cross-compound, condensing 24, 46 and 70 by 60 in. and are in continuous operation, each averaging 32,900 revolutions per day. The steam pressure at the throttle was 170 lb. gage, no superheat, 28 in. vacuum. The oil is fed by a three-feed force pump, each feed being tapped close to the steam valves (Corliss-type valves) of the respective cylinders. Result of oil test—specific gravity Baumé 26.3 deg. viscosity 172, flash 618 deg. F., fire 680 deg. F.

In a run of 24 hr. 6.13 pints of oil was used, at 22c. per gal., making the total cost for cylinder lubrication 16.86c. Oil of 26.3 deg. Baumé = 0.895 specific gravity = 119.36 oz. of oil per gal.; 6.13 pints = 91.45 oz. of oil. In the 24 hr. 12,045,000 sq.ft. of cylinder surface was swept by piston, resulting in a consumption of 7.59 oz. of oil per 1,000,000 sq.ft. at a cost of 1.39c. per 1,000,000 sq.ft.

J. W. BEATTY.

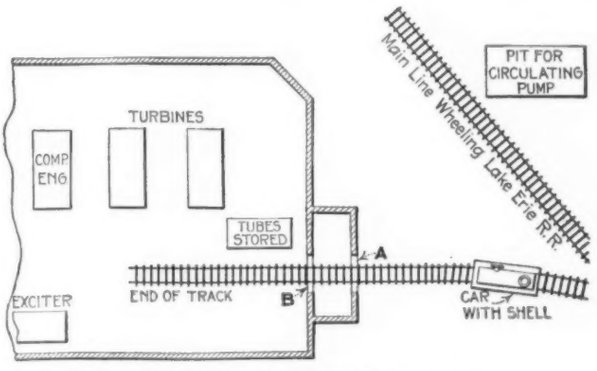
Chicago, Ill.

*Other discussion on this subject will be found in the issue of Feb. 22, page 266 and Mar. 29, page 447. Another series on a similar subject, "Cutting Down Cylinder Oil," appeared in "Power" Nov. 2, 1915, p. 602 Nov. 30, 1915, p. 673; Jan. 4, 1916, p. 23; and Jan. 11, 1916, p. 53.

Transferring Large Condenser

The following plan of an erecting engineer to overcome a difficulty in transferring a large condenser shell from a car to its foundations may be of interest.

It was found that the condenser loaded on the car would not clear the entrance doors through which the



ENTRANCE DOORWAY TOO LOW

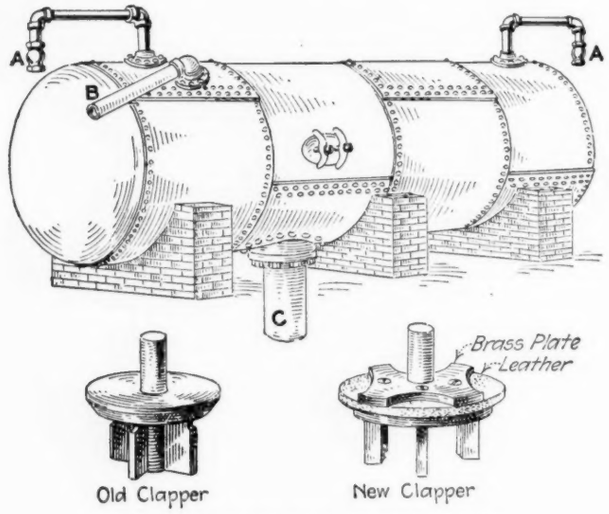
track ran, by 4 in. The car was jacked up, and the wheels and trucks were rolled from under it. It was then lowered onto rollers, and in this way it was brought into the building within reach of the traveling crane.

New York City. PAUL A. BANCEL.

Check Valves To Hold Air

A 5,000-gal. tank, located on the top floor and furnishing gravity water pressure at 80 lb. for the pilot valves of the hydraulic-elevator system, has an overflow pipe leading to the gutter of the gable-roofed building. The end of this pipe was one cold day sealed up with snow and ice, and there being no other vent, a vacuum was created in the tank, which prevented the water from flowing.

The tank had a section of 2-in. pipe extending upward and outward from the top of the shell near each head and plugged at the ends. Two 2-in. taper-ground brass check valves were put on these pipe ends opening inward, but they were not suitable for air, so they were removed and altered as follows: After boring the diameter of the seat large enough to remove the taper, it was bushed down ¼ in., giving a larger seat bearing, and then faced off flat.



LEATHER DISK FOR CHECK VALVE

A new clapper was made, with four guides and a leather disk ⅛ in. thick was held in place by a ⅛-in. brass plate screwed fast to the clapper.

The valves as altered, when placed in position on the tank, were found to be very sensitive, keeping the proper air pressure on the water. W. T. Osborn.

Newark, N. J.

Care of Belts in Service

Engineers have much to do with the buying and supervision of belts, and for that reason I am going to point out a few of the "little things" that are too frequently overlooked on the belt side of the ledger. From the time we were children we were supposed to be taught the importance of little things. So I believe it an important enough detail to call attention to belt lacing and dressing. They are seemingly small, yet they are big.

Each year, let us say, there is bought $2,000 worth of leather belting. This is a "whole lot," so you give the deal your own personal attention and are careful to buy the "best" for your purpose. After this purchase you turn the belting over to anybody who happens to be in need of it and allow that person to do about as he pleases with it. He "butchers" it with large enough holes for the insertion of rawhide laces, thinking, as many do, that the larger the lace the stronger the joint. This is not true. It would be much better if holes were not punched in a belt at all, for every hole cuts away just so much of the useful section of the belt. That is why endless belts are strongest.

Belts are cemented more easily nowadays than they were a few years ago, because of better equipment for doing the work. We can profit by the experience of our predecessors. For example, in the "old days" they did not think it possible to shorten an endless cemented belt without inserting a piece on account of the belt laps. Now, however, it is done very easily. We just "slice" the belt twice along the proper beveled line, at the proper distances apart, including an old joint in the portion sliced out, and then we cement the belt together again. If this is done at the regular closing-down time, the belt is ready for use again next morning in better condition than ever. The time required to do the work with a modern equipment is practically nil.

The endless belt is generally best, but where it cannot be used handily, a lacing should be used that most closely approximates the cemented joint in strength, smoothness and flexibility. The wire joint is fast approaching this desired condition. I have seen wired joints that are noiseless in their operation; they are almost as flexible as the cemented joint both ways—laterally and longitudinally; and they are almost as strong, because very little of the belt's section is cut away when the wire lace is driven into the belt. The wire prongs just "displace" the belt fibers and shove them to one side, where they still assist in holding the belt together; not so where round or oblong holes are "punched out." Poor lacing is one of the principal causes for premature belt destruction. There is no reason why this work should be poorly done. Belt lace is very cheap in comparison with the first cost of a belt, so why skimp when it comes to laces? The best is the only kind that should be used. Make belts endless or make them approach the endless condition—that is the best rule I know.

Next comes the dressing. Do you pay any attention to what your men put on the belts to keep them from slipping? Do you permit the use of rosin, soap, neat's-foot oil, castor oil, lime, boiled linseed oil or any of the other dopes that we see recommended so frequently? I have used shellac on belts and it helped "for a while," but it did not do the belts any good. And the same is true of the other things mentioned. Neat's-foot oil and castor oil are not so bad, but why use them when there are better dressings available? Since a dressing is so vital to the belt's condition and life, it is apparent that only the best should be used, and dressings do not cost much as compared with belts. Through proper treatment with proper dressings and with the correct lacing, belts can be made to run two, three, four and even twenty times as long as where the "small things" are improperly done.

It is difficult to give actual figures in an article like this, because no two drives are exactly alike. There are so many variables to contend with—belt width, belt speed, belt thickness, belt strength, pulley diameter, roughness of pulley face, pulley alignment, temperature, humidity, dust, grease, etc.—all of which affect belts. They are all "small" things, but they are all-important. I cannot even say that lacings and dressings are more important than pulley alignment, humidity conditions or dust conditions, because sometimes they may be and again some-

times they may not be so important. It "all depends," as we often indefinitely remark. My advice to the engineer who has the supervision of belts is, therefore—attend to the "little things" that are more important than the buying. Perhaps you can save that $2,000 next year, and for several years. It is worth while.

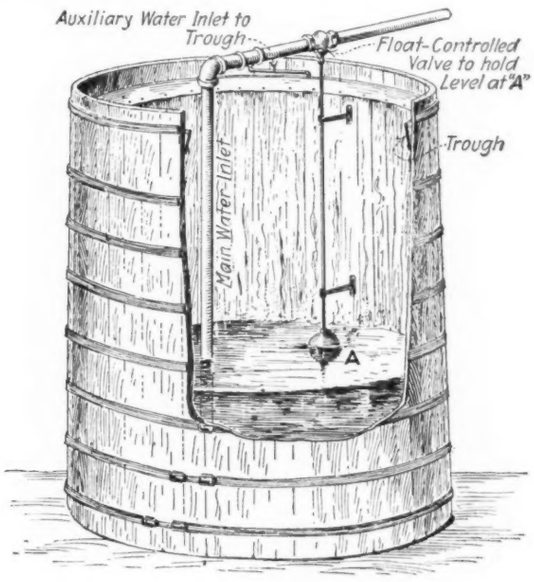
Investigate some of the belts that have successfully operated for 20 years without even being shortened once. Find out how it is done. Learn how the belts are aligned, laced, dressed, etc. Perhaps you will then learn that it pays to spend a dollar or two more per year for the best belt auxiliaries and in the end save money that may run into the hundreds or thousands. S. F. WILSON.

New York City.

Preventing Tank Staves Drying

In one of our process rooms there is a wooden tank 12 ft. in diameter by about 14 ft. high, in which a very low water level was being carried—only about 4 ft. from the bottom. Because of the dry hot atmosphere in this low room, it was difficult to keep the top section of the tank from drying out and warping. This could not be permitted because it might be necessary at any time to fill the tank almost to the top on short notice.

The difficulty was overcome by a small bleeder, or bypass pipe, taking water from the main supply pipe and discharging into a tin trough inside of the tank near the top. The bottom of this V-shaped trough was not made water-tight, so the water was allowed to trickle from its bottom edge down along the side of the tank, keeping it from drying out. The illustration shows the general arrangement. W. SAILES.

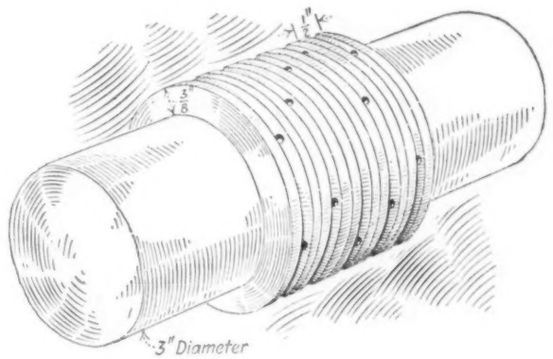


SPRAY TROUGH INSIDE OF TANK

Philadelphia, Penn.

Gas-Engine Piston-Rod Packing

One of the bugaboos of the double-acting gas engine is the piston-rod packing. Different schemes have been tried by the makers, but often the operating engineer has to discard them and put in a packing of his own devising. This was true with our tandem two-cylinder engine operating on coke gas. Its cylinders are 13 in. diameter, and the stroke is 16 in. The pistons and the continuous rod—made in three pieces and jointed in the crossheads—are carried by three crossheads, thus relieving the packing rings of any weight.



SHOWING HOW PACKING WAS APPLIED

When installed, the engine had compression-spring rod packing, which gave trouble, as it either got too hot or ran so loose as to blow through.

The engineer, who was an experienced marine man, devised a solid-ring packing that has been giving complete satisfaction. These rings were made a close sliding fit on the rod, and each ring has a groove turned in its periphery and several oil holes drilled clear through, as shown in the accompanying sketch. The rings were made of cast iron ⅜ in. deep and ½ in. wide. Five of these are used for each of the four packing sets. The rods had to be disconnected from the crossheads to slip the set of rings on the respective sections. The set is held in place by the usual gland and studs. F. W. BRADY.

Scranton, Penn.

Hot-Water Heating Problem

The principles involved in hot-water heating, even such as is used in private dwellings, may well be considered a part of an engineer's education. A thorough knowledge of the proper design and construction of boilers is also considered essential to success. If an engineer is asked to describe the operation of the ordinary gravity-return hot-water heating system he is likely to tell you that "heat applied to the water in the boiler causes the water to become lighter and it rises through the pipes to the radiators, where the heat is extracted and it becomes heavier and so returns to the boiler through other pipes, and it is again heated and passes through the same cycle." Unfortunately it is not as simple as it seems at first sight. As a matter of fact, hot-water heating requires considerable study, if one has to do with the installation of such systems.

Some time ago I undertook to run a line of pipe to heat a garage some 35 ft. from the house. The garage floor was about level with the boiler-return header. The installation, as shown in Fig. 1, looks as though it should give satisfactory results, but unfortunately it failed completely. When the feed valve *F* was opened, hot water from the boiler filled the coil and piping, but as soon as the return valve *R* was open, all flow stopped and the coil would gradually cool off, as there was no circulation.

A number of experiments were tried. First the coil was raised to the dotted position with no good results. Next the return line in the cellar was raised, as shown in the dotted line, and the coil slanted so that the end nearest the boiler would be lowest, but no improvement

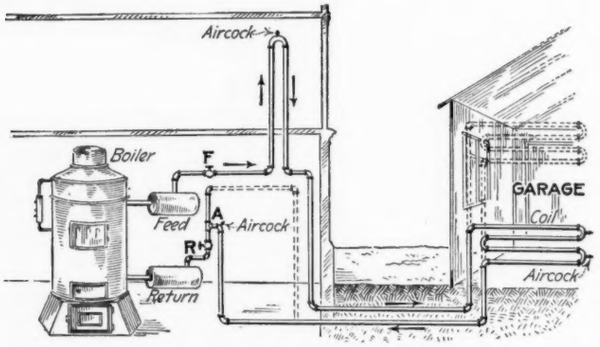


FIG. 1. GENERAL LAYOUT OF LINE TO EXTRA COIL

resulted. I then began to think air pockets would bear some looking into, so the following changes were made:

At the top of the loop a larger air vent was placed, the coil in the garage and the return pipe were lowered to their original positions and graded to give a gradual flow from the inlet to the outlet, and in each return bend an air-cock was placed, thus eliminating any chance for air pockets. An air-vent was placed in the highest part of the return piping just above the return valve at *A*. When the feed valve was opened and the system filled with water and thoroughly purged of air, the

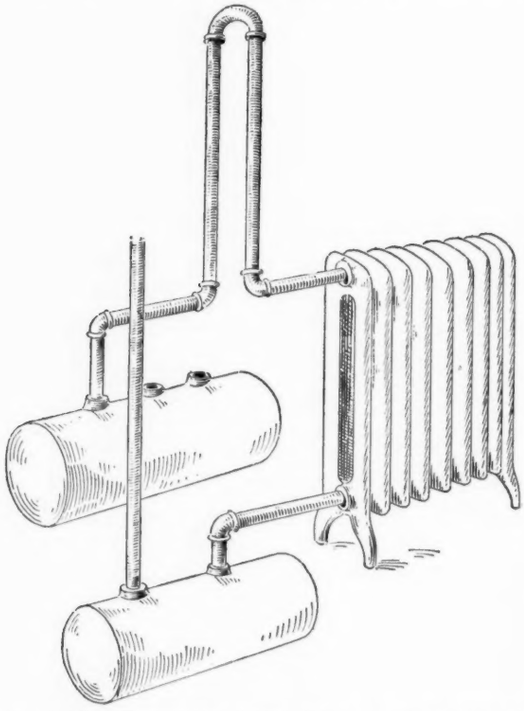


FIG. 2. LOOP IN SUPPLY LINE TO ASSIST CIRCULATION

return valve was opened and circulation was at once established. It would seem that air must have gathered at the high point in the return pipe just above the valve, and as this pipe was not vented, it blocked all circulation.

The use of the loop may be explained as follows: Circulation in a hot-water heating system depends upon the difference in the weights of hot and cold water. One cubic foot of water at 40 deg. weighs 62.4 lb., and at 140 deg. it weighs 61.3 lb., a difference of 1.1 lb. This difference in weight creates a circulation, and the higher the radiator is above the boiler the better the circulation, owing to the greater difference in weight. If a radiator is placed level with the boiler, the difference in the temperature will have to be great to cause the difference in weight necessary to create a circulation. In practice the difference in the temperature is usually less than 100 deg., and in a short connection, as shown in Fig. 2, the lower part of the radiator would have to be almost cold when the upper part was hot. To overcome this the loop is placed in the distributing, or flow, pipe, as shown, to get the same conditions as with the radiators on the upper floors and to get a head of water to overcome the tendency of the returns from other risers backing into this part of the system. The greater the difference in the temperature of the water in the two pipes of the loop the better the circulation will be in the low radiator, but by lowering the temperature of the water in the return pipe of the loop the temperature of the water that must be used to heat the radiator is lowered also and therefore the capacity of the radiator. The better way, of course, is to raise the temperature in the distributing pipe up to the top of the loop, and this can be done by covering or enlarging the pipe up to that point.

ARTHUR D. PALMER.

Dorchester, Mass.

Troublesome Fuel Valves in a Diesel Engine

While running a four-stroke-cycle four-cylinder vertical Diesel engine, we had considerable trouble due to the fuel valves sticking open. This allowed an excessive amount of fuel oil to enter the cylinder and caused a dangerous-sounding explosion, besides subjecting the cylinder-head bolts and the head itself to excessively high stresses.

An examination of the valve stems showed that a dark gummy substance was baked on them and was rapidly wearing out the packing. This made the valves leak, and it was usually when we were tightening up on the packing to overcome this leak that we experienced the trouble of having the valves stick.

We traced this gummy substance back to the air line and thence to the compressor. It was then decided to put a comb in the air line between the high-pressure compressor cylinder and the blast-air bottle. By blowing out this comb and draining off the oil from the intercooler coils at frequent intervals, we succeeded in cutting down to a considerable extent the amount of oily matter carried over with the air.

The temperature of the cooling water was also carefully watched, and it was found that by running this at a lower temperature than formerly—that is, at about 55 deg. C.—the valves worked better and the gum was much easier to clean off.

By making these changes and by cleaning the stems regularly, the sticking of the valves was finally entirely done away with, much to the gratification of those who had to work around the engine.

Erie, Penn. THEODORE M. ROBIE.

Inquiries of General Interest

Assistance of Suction Pressure—What effect has suction pressure on the power required for running a direct-acting steam pump? H. T. C.

Pressure acting on the suction side of the pump assists the power to move the water piston against the discharge pressure and thereby reduces the power required to operate the pump as much as though the same total pressure had been removed from the discharge side of the water piston.

Submergence of Air-Lift Pump—What is meant by depth of submergence and percentage of submergence of an air-lift pump? G. S.

In air-lift pump practice, the term submergence refers to the air pipe. The depth of submergence is the depth at which the compressed air is liberated in water, measured from the free water surface outside the discharge pipe. The submergence ratio, or percentage of submergence, is the quotient obtained by dividing the depth of submergence by the total air lift measured from the point at which air is liberated in the water pipe to the level at which the water is discharged.

Overcharging of Lead Storage Batteries—What effect has overcharging on lead storage batteries? T. R. D.

An overcharge at certain periods is desirable to the maintenance of a battery in good condition, the frequency of overcharge depending upon the service. An overcharge should not be carried too far, however, nor should it be given at very high rates, for then the temperature is apt to be excessive and injury to the battery will result. The overcharge should be carried to the point at which the specific gravity of the electrolyte has ceased to rise for four or five consecutive 15-minute observations and the cells are gassing freely.

Brake Power Developed by Engine—How is a determination made of the net, or brake, horsepower developed by an engine in driving a given load? M. C.

An actual brake test can be made of the engine when developing the same indicated power as when driving the given load, but for all practical purposes it is sufficient to obtain the net, or brake, power developed by taking the difference between the indicated power when driving the given load and the indicated power developed by the engine under the same conditions of speed, adjustment and lubrication when doing no other work than overcoming its own friction. This method of computing the brake power developed is not strictly correct, for the friction of the engine does to some extent increase with the load, but the proportional increase is so small that, for ordinary speeds and steam pressures, the friction of the engine with different loads may be regarded as practically constant.

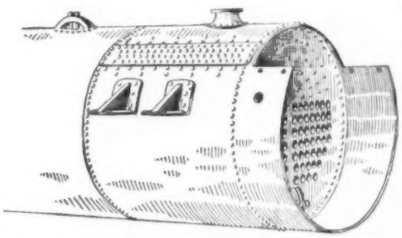
Power Required for Operating Feed Pump—What power is required for operating a belt-driven boiler-feed pump of a boiler that supplies steam at 100 lb. gage pressure to an engine developing 300 i.hp.? J. R.

Assuming that 30 lb. of feed water is required per i.hp. per hour, the quantity of water handled would be $(300 \times 30) \div 60 = 150$ lb. per min., and allowing the frictional resistance of the feed line to be 5 lb., the pump would discharge against a pressure of 105 lb. per sq.in. Each pound of pressure pumped against would be equivalent to raising the water through a height of 2.3 ft., and pumping against a pressure of 105 lb. per sq.in. would be equivalent to raising the water $105 \times 2.3 = 241.5$ ft., requiring the development of $(241.5 \times 150) \div 33{,}000 = 1.097$ hp. The mechanical efficiency of the pump would depend on its construction, condition and adjustment. Allowing an efficiency of 50 per cent., the net power required for operating the pump would be $1.097 \div 0.50 = 2.194$ hp.

Loss of Pressure from Elbows in Feed Line—What would be the loss of pressure due to eight 90-deg. elbows in a 1½-in. boiler-feed line for supplying 250 boiler horsepower? B. N.

The loss of pressure would depend on the roughness of surface and abruptness of bend of the elbows and the rate of discharge of feed water. With ordinary short-turn elbows, the loss of pressure per elbow would be equal to that from a pipe of the same size and having a length equal to about 65 diameters; that is, the total loss of head would be about the same as for the same rate of discharge through $(8 \times 1.5 \times 65) \div 12 = 65$ ft. of 1½-in. pipe. Assuming that 250 boiler horsepower would require $(250 \times 30) \div 60 = 125$ lb. or about 15 gal. of water per minute, the loss of head from friction would be about 3 ft., or $3 \times 0.433 = 1.299$ lb. per sq.in. per 100 ft. of 1½-in. pipe. Hence the loss of pressure due to the elbows, equivalent to that due to 65 ft. of 1½-in. pipe, would be $(1.299 \times 65) \div 100 = 0.844$, or practically 1 lb. per sq.in.

"Dry Sheet" of Return-Tubular Boiler—What is the dry sheet of a horizontal return-tubular boiler? H. B.



DRY END OF HORIZONTAL RETURN-TUBE BOILER

The term "dry sheet" is sometimes applied to the front-end sheet of a return-tubular boiler when it extends beyond the front head to form an uptake as shown in the sketch. Boiler makers more commonly refer to the sheet as "curtain sheet," "extension sheet" and "dry end." "Dry sheet" is probably a corruption of the term "dry end," and strictly speaking, the term "dry sheet" should apply to a separate sheet that is attached to the end shell sheet of the boiler for forming the whole or part of the extension.

Pressure Tending to Force Mud Drum Off Nipples—How is a computation made of the pressure tending to force the mud drum of a water-tube boiler off the nipples? N. B. C.

The pressure within the mud drum tending to force it off each nipple would be the same as the force or pressure that would be exerted by the pressure in the mud drum acting on a plug or piston of the same area as the hole in which the nipple is expanded. If, for instance, the diameter of the hole is 4 in. and the pressure within the mud drum is 125 lb. gage, then the total pressure tending to force the mud drum off the nipple or draw the nipple out of the mud drum would be $(4 \times 4 \times 0.7854) \times 125 = 1{,}570.8$ lb. If the mud drum is suspended from the nipple then the weight supported plus the total pressure tending to force the mud drum off the nipple will be the total force tending to draw the mud drum off the nipple. If, however, the boiler rests on the mud drum, the boiler pressure tending to draw the nipple out of the mud drum will be reduced by the weight of boiler material that is concentrated at the nipple.

Cooling Water Required for Surface Condenser—What quantity of cooling water would be necessary to condense 1 lb. of steam under the following conditions: Initial temperature of the cooling water, 60 deg. F.; final temperature, 100 deg. F.; vacuum, 26 in., referred to 30 in. barometer? L. I.

The amount of cooling water per pound of steam is given by the formula

$$W = \frac{H - t_1 + 32}{t_2 - t_0}$$

where

H = Heat content of the exhaust steam above 32 deg. F.;
t_1 = Temperature of the condensed steam;
t_0 = Initial temperature of cooling water;
t_2 = Temperature of the discharge water;
W = Pounds of cooling water necessary to condense 1 lb. of the steam.

By referring to the steam tables it is seen that H, the total heat of 1 lb. of steam at 26 in. vacuum or $30 - 26 = 4$ in. mercury pressure, absolute, is 1,115 B.t.u., and t_1, the temperature of the condensed steam, is 126 deg. F. By substituting the formula becomes

$$W = \frac{1{,}115 - 126 + 32}{100 - 60} = 25.5 \text{ lb.}$$

of cooling water per pound of steam.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Advocates Private Development of Water Power

After a stormy three-day session, in the course of which the organization nearly split, the National Conservation Congress, meeting in Washington, D. C., indorsed the plan of allowing private concerns to take over and develop the water-power resources of the West.

The vote (116 to 39) marks the end of a long factional fight between the Pinchot element of the congress and the members who desired to see the national water-power resources developed within the near future, irrespective of whether the control should pass into private hands or not. At the last session of the congress, held three years ago, Pinchot and his adherents were victorious. At the session just concluded, the positions were reversed and the delegates voted to sustain the majority report of the Water Power Committee by about three to one.

Immediately prior to the voting, Gifford Pinchot, formerly Chief Forester of the Department of the Interior, made the direct charge that underhand methods had been employed by the water-power interests to have the congress indorse the Shields and Myers bills, which will permit of private exploitation of water-power resources.

M. L. Alexander, of New Orleans, chairman of the committee on credentials of the congress, resented the charge and stated that every delegate's credentials had been examined and that no evidence of a "packed" convention had been discovered. Following this announcement, Charles S. Barrett, president of the National Farmers' Union, Union City, Ga., who was presiding officer at the time, asked to be relieved of the chair and repeated the charge made by Mr. Pinchot that the convention was "packed." President Worsham quelled the confusion by calling for an immediate vote, which stood 116 votes in favor of private development and 39 against it.

PINCHOT CHARGES FRAMEUP

Before leaving the convention, Gifford Pinchot issued the following statement to the press:

The National Conservation Congress has been captured by the water-power interests. It was the old, old story—special interest up, public interest down. The water-power men used their control to drive through an indorsement of the iniquitous Shields and Myers bills, which propose to give away in perpetuity the last great natural asset still in the public hands. By doing this, public confidence has been killed in the Conservation Congress and an end has been put to its usefulness.

In the past the Conservation Congress has done good work. Formerly it was an open forum in which great questions were discussed in the light of the public welfare. It has now become an annex to the water-power lobby, of whose activities Washington has seen so much during the past winter. The committe on water power, whose recommendations the congress accepted, was completely controlled by the representatives, among others, of the Utah Power Co., the Georgia Power Co., the Alabama Power Co., the General Electric and the Aluminum Co. of America, which has great interest in water power.

The proceedings today hurt the congress far more than they helped the water-power men. The assiduous gentlemen who knew exactly what they wanted and got it may find that they have overshot the mark. The more the water-power lobby comes out into the open the easier it is to beat. It came out today where all men could see it. That fact will be of great assistance to the men who are fighting the Shields and Myers bills.

President Worsham and other prominent officers of the Conservation Congress ridiculed Mr. Pinchot's statement, saying that the "myth of the water-power lobby" had been proven false long ago.

The acrimonious debate over the water-power question started when B. M. Hall, of Atlanta, Ga., chairman of the committee on water power, moved that the majority report of the committee, which recommended the indorsement of private development, be adopted. E. C. Finney offered a minority report, opposing the Shields and Myers bills on the ground that they would take the water-power resources out of the hands of the country and place them under the control of private corporations.

The two committee reports were in part as follows:

MAJORITY REPORT OF COMMITTEE

In advocating a policy of power conservation, there must be a fine adjustment between that water-power development which is thoroughly practicable and that which becomes impracticable by reason of the fact that fuel power can be produced at a lower cost. A water-power site is valuable only when it is useful, and it cannot be useful if the cost is greater than that necessarily expended in producing an equal amount of mechanical energy by some other means. The saving of a resource for the benefit of a future generation is a noble sentiment which should be carried into effect wherever practicable. It should not be forgotten, however, that the welfare of a future generation depends quite as much on the prosperity of the present generation as it does upon the store of resources which the present generation leaves to the future.

The average unit cost of water-power development is about three times as great as that of steam-power development. Of course conditions differ in different sections of the United States. There are places where, by reason of the high cost of coal or other fuel, it is economical to develop water power notwithstanding the much higher installation cost. On the other hand, there are places where water-power development, even though it may be made at relatively low cost, is not practicable because of the extremely low price of fuel in that place. Some of the lowest-cost power produced in the United States today is steam power, and certain steam installations now under construction will produce power at a price cheaper than that reached by any hydro-electric plant now installed in this country.

Considering the country as a whole, we are comparatively safe in the statement that water power may be produced somewhat cheaper than fuel power and in some places the margin is considerable. Because of the lack of a forward water-power policy, we are paying about $500,000 per day for coal which might, on a practical and economical basis, be saved by the substitution of water power. In addition to this there is an enormous present demand for hydro-electric power in new markets and extensions of old ones, representing a conservatively estimated total of 4,000,000 hp.

All efforts to progress are based on the expectation of reasonable reward. Government ownership and operation of water powers may or may not be a settled policy of the future. It is apparent, however, that for a period of years the greater part of our water-power development must be accomplished by private capital. This being the case, such development must be voluntary on the part of private investors and must be induced by a promise of reasonable reward and an assurance of the safety of the principal invested. There can be no escape from this conclusion. Therefore the public must, if it would derive immediate advantages from its water-power resources, extend such reasonable assurances to investors, and at the same time hold fast to the control of rates, service and all conduct, provide for a fair deal to all concerned and reserve the right to recapture the properties on payment of the fair value thereof at the end of a stated period.

There are those who would impose upon the development of water power advance penalties for the presumptive doing of wrong. They consist of limitations in operation, in market and in property title. They promise confiscation of property, unrestrained taxation and speculative securities. In the sovereign control of water power as in the sovereign control of everything else, the guilty should be punished and the innocent should be encouraged, but no progress will be made by assuming at the outset that the innocent will soon become the guilty and therefore all should be placed under restrictions that make success impossible.

There are before Congress two water-power bills which comprise the best thought of the day and represent a reasonable common ground upon which all may safely stand for the present at least. We hereby indorse both of these measures in principle and express the hope that they may be speedily enacted into law.

MINORITY REPORT OF COMMITTEE

We are opposed to the unqualified indorsement of these measures (Shields and Myers bills) not only because we believe it unwise to so indorse any pending measure, but because the particular measures indorsed are objectionable in part, and we believe that the public interest requires their radical amendment. The measures do not provide for such control over the permits or leases, over the sale or delivery of power, or over the regulation of rates and service and the issuance of stocks and bonds, as is essential if the consumers and the general public are to be regarded and protected. Neither are the provisions for taking over or recapture at the end of the periods prescribed or of the things to be taken into consideration in rate making satisfactorily drawn to safeguard the public interest.

There are numerous other objections to these measures, and we earnestly hope that the National Conservation Congress, popularly believed to represent the best thought of the country and devoted to the public welfare, should refuse to put its stamp of approval upon the majority report, in so far as it in any way approves or indorses the measures herein described.

The minority then offered a substitute resolution embodying in part the following:

That the application of electrical energy to everyday uses over a widening area of distribution, including interstate distribution and use, which use affects, directly or indirectly, all the citizens of the United States, as well as the fact that physical combination of water-power systems is in many instances necessary and desirable for reliability of service, for the more complete utilization of the power and in the interest of economy, makes it necessary in the public interest that these sites shall not be disposed of in perpetuity, but shall be retained in Federal control, to be developed and used under such liberal rules and for such certain and definite tenure as will encourage the use of private capital therein, and that the development should be under such public control that the consumer, the operator and the investor will all receive fair treatment.

The afternoon session of the first day was devoted to a discussion of the conservation problems of the various sections of the United States, each district being discussed by a resident familiar with its needs and resources.

The first evening session was taken up with a lecture by C. J. Pierce, of Seattle, on "Water-Power Resources and the Manufacture of Atmospheric Nitrogen." This lecture attracted unusual attention.

Reports of the various committees, notably those on soils, iron, mineral fuels and forests, consumed the greater portion of the morning session of the second day. W. L. Saunders, vice-chairman of the Naval Consulting Board, contributed an interesting paper on the functions of the modern engineer and the conservation of natural resources.

The forestry committee's report, presented by Prof. J. W. Toumey, of Yale University, pointed out that in case of war great quantities of wood pulp and rosin would be used in the manufacture of explosives and surgical supplies. It recommended that the Government adopt a permanent policy of acquiring land in the Appalachian region by purchase and in the Western forests by consolidation and extension; also, that the more wealthy and progressive states, municipalities and private corporations of a semi-public nature might set an example in the acquisition and cultivation of forests.

The need of conservation in the iron products of the United States was pointed out by E. F. Burchard, of the United States Geological Survey, chairman of the committee on iron. Mr. Burchard predicted that at the present rate of consumption the iron-ore deposits of the country would be used up in 150 years.

A brief report, submitted by R. G. White, chairman of the committee on mineral fuels, stated that 99.5 per cent. of the coal of the country is still in the ground, that there is an immense reserve of oil, that the deposits of both these products are well distributed and that mobilization of these resources would involve only the securing of miners and cars.

The final day of the congress was taken up with the adoption of a resolution advocating the use of water power for the production of nitrates for commercial purposes in time of peace and to be available for the use of the Government in any emergency, indorsement of the work of the Naval Consulting Board for industrial preparedness and the reports of the committees on wild animal and bird life, human resources, the prevention of illiteracy, the nation's health and educational preparedness.

The delegates to the congress left Washington apparently well-satisfied with the business transacted during the convention and confident that next year's session, at New Orleans, would be a complete success.

The Code in Pennsylvania

In conformity with law a public hearing was held in the State House at Harrisburg, Penn., on May 2, by the Industrial Board of Pennsylvania, to consider questions relating to the adoption of the Boiler Code which is to become operative in that state on July 1 of this year. About 30 were present. Commissioner John Price Jackson of the Department of Labor and Industry presided at the meeting.

The morning session was practically taken up by three speakers. E. A. Wildt, of Scranton, Penn., asked that autogenous welding by the electric method be accepted for the boilers that he builds; that is, that an exception be made in the case of his boiler to the requirement that where the longitudinal seam of a boiler was welded, the weld must be made by pressure. J. C. Parker, of Philadelphia, objected that he would not be permitted to use malleable iron headers for more than 160 lb., while be contended that their use was perfectly safe for 300 lb. working pressure.

Capt. James Rees, of Pittsburgh, made an extended plea against the use of the Code, his three principal points of objection being that lap joints should be used, that lever safety valves should be permitted and that the cold driving of rivets should be allowed. He stated that a lap joint had never been the cause of a boiler explosion. In the afternoon session it was brought out that Captain Rees now was driving rivets hot, because he could not get the proper rivet material for cold driving. Although there were a number of prominent boiler manufacturers present and their opinions were asked by the chairman on the points brought out by Captain Rees, no one could be found who would agree with him on any of the points raised. Commissioner Jackson made it plain that all criticisms of the Code would be given careful consideration by the department's engineers after consulting with all sources of information available, either inside Pennsylvania or out, and that the Code Committee of the American Society of Mechanical Engineers would be asked to advise the Bureau of Inspection on proposed changes.

Among the speakers at the afternoon session were Thomas E. Durban, of Erie, Penn., who spoke in favor of uniformity, also H. B. Goodling, of York, Penn., representing the Agricultural Manufacturers Association, who stated that the interests he represented were entirely in favor of the Code and considered the compliance with its provisions to be without hardship to the boiler manufacturer. The boilers proposed by the department for exemption from inspection were: Railroad locomotives subjected to inspection under Federal laws, boilers used in railroad construction, boilers on automobiles, boilers on steam fire engines brought into the commonwealth for temporary use in times of emergency for the purpose of checking conflagrations, boilers carrying pressures of less than 15 lb. per sq.in., which are equipped with safety devices approved by the Industrial Board, and boilers under the jurisdiction of the United States. The only objection raised to this was by the threshermen, who desired agricultural boilers to be exempt from inspection.

The Industrial Board promised the boiler manufacturers its best efforts toward securing action by the various states having boiler laws or enacting boiler laws to adopt uniform methods of reporting and inspecting, to the end that boilers built under the inspection and rules of one state may be accepted by other states having similar laws.

Bureau of Standards Forum

A conference meeting of the United States Bureau of Standards and representatives of a large number of companies operating Southern lighting and power plants was held under the auspices of the Affiliated Technical Societies, in Atlanta, Ga., May 2, 3 and 4, at which meeting the subjects of electrolysis and the grounding of low-potential electrical circuits were discussed at considerable length.

The Bureau of Standards has been working for several years on a National Electrical Safety Code, and the discussion at this meeting added to the data thus far collected and confirmed the wisdom of the work already accomplished. Prof. E. B. Rosa, of the bureau, presented a tentative draft of the proposed code, as far as it has been definitely formulated, and this received practically unanimous commendation from the power-plant delegates. The code is too extensive and ramified to permit even an abstract of it that would convey an adequate idea of its provisions.

In a paper on grounding low-potential systems, Burton McCollum, of the Bureau staff, pointed out that the grounding of the same metallic neutral to underground piping, etc., in several places could cause serious trouble from electrolysis, because the underground system would thereby be put in parallel with the neutral conductor of the electrical system and current would therefore be shunted through the pipes. No such trouble could occur, however, from grounding the secondary neutral points of any number of transformers fed from the same supply source but connected to separate secondary circuits.

National and State Conventions

American Order of Steam Engineers, New York City, June 26-30.
Canadian Association of Stationary Engineers, Montreal, July 24-28.
Universal Craftsmen Council of Engineers, Pittsburgh, Penn., Aug. 8-12.
National Association of Stationary Engineers, Minneapolis, Minn., Sept. 11-16.
International Union of Steam Engineers, Newark, N. J., Sept. 11-16.

N. A. S. E. STATE ASSOCIATIONS

California	Santa Barbara	May 26-28
Connecticut	New Haven	June 23, 24
Illinois	Peoria	June 7-9
Indiana	Kokomo	June 21-23
Iowa	Waterloo	May 17-19
Kansas	Pittsburg	May 3-5
Kentucky	Louisville	June 27-29
Michigan	Kalamazoo	July 19-21
Minnesota	Minneapolis	Sept. 11
Missouri		
New England States Association	Fall River, Mass.	July 12-15
New Jersey	Paterson	June 1-4
New York	Yonkers	June 8-10
Ohio	Dayton	June 15-17
Pennsylvania	Williamsport	June 16, 17
Texas	San Antonio	
West Virginia	Clarksburg	
Wisconsin	Fond du Lac	Aug. 3-5

Boiler Legislation

Thomas E. Durban, chairman, American Uniform Boiler Law Society, which aims to extend the legal adoption of the A. S. M. E. Boiler Code, reports as follows:

The writer visited in Chicago Edward W. Lloyd, president of the National Electric Light Association; Fred Sargent, of Sargent & Lundy; James L. Foord, of the Hartford company; and Louis Mohr, of John Mohr & Sons Co. Headed by these gentlemen, a movement was started to overcome the prejudice that existed against the Code and give the Code a start in Chicago and in the state. Louis Mohr has taken charge of the

situation there, and we expect to be able to show some results in the near future.

In Louisiana we have placed the matter in the hands of W. H. P. Creighton, dean of the College of Technology of Tulane University, Andrew Lockett and W. O. Hart. We understand that the Louisiana Engineering Society has a resolution up indorsing and approving the Code, which will have its final reading after it has been duly circulated among the members.

The legislature meets in Louisiana in May, and we hope to have the matter in such shape that we can get a proper bill introduced and passed.

In Texas we are making an effort to get the support of the Cotton Ginners' Association. We have taken the matter up actively with Mr. Weaver, of Briggs-Weaver Co., Messrs. Smith & Whitney, engineers at Dallas, and with other interested people at San Antonio, El Paso and Houston, and we believe that if we can get the support of the Ginners' Association and the Murray Co., we will have a fair chance of getting the proper legislation passed at the next session of the legislature.

The Boiler Code Bill which was introduced in New York States has passed the House unanimously. This probably means its ultimate passage, although of course it has to go through the Senate and be signed by the Governor.

ENGINEERING AFFAIRS

The Blue Room Engineering Society of Greater New York held its regular monthly meeting at 103 West 38th St., on Thursday evening, May 11, 1916.

The Chicago Section of the A. S. M. E. was addressed on May 15 by Joseph Harrington, advisory combustion engineer, Chicago, on "The Use of Powdered Coal as Fuel."

Stevenson Association No. 44, N. A. S. E., is to have its spring hike on May 14 and its family outing and games on Aug. 6, at Midland Park, Grant City, Staten Island, N. Y., according to Fred Felderman's lively and interesting little sheet, "The 44 Booster."

The American Boiler Manufacturers' Association will hold its twenty-eighth annual convention at the Hollenden Hotel, Cleveland, Ohio, June 19 and 20. Among the subjects that will come up for consideration will be data on uniform cost system and progress toward adoption by various states of the A. S. M. E. Boiler Code. One or two plants of interest to boiler manufacturers will probably be visited.

Minnesota Students' Inspection Trip—Ten students of the electrical-engineering department of the University of Minnesota, in company with Prof. G. D. Shepardson, returned to Minneapolis, Apr. 29, after visiting electric power generating and electrical machinery manufacturing plants in the northern Mississippi Valley and in Chicago and Milwaukee. They inspected the Keokuk dam, the Hawthorne plant in Chicago of the Automatic Electric Co. that is now installing automatic telephones for the Tri-State Telephone and Telegraph Co. in Minneapolis; the Allis-Chalmers plant in Milwaukee, and that of the Thordarson Electric Co. in Chicago. This last-named company recently furnished the university a 300,000-volt transformer for testing purposes. The students declared they had learned much from the visit.

Illinois Industrial Preparedness Committee Organizes—The Illinois State Board of Directors of the Organization for Industrial Preparedness consists of William Hoskins, member of the American Chemical Society; Capt. Robert W. Hunt, member of the American Society of Civil Engineers; Peter Junkersfeld, member of the American Institute of Electrical Engineers; F. K. Copeland, member of the American Institute of Mining Engineers; and Dean W. F. M. Goss, member of the American Society of Mechanical Engineers. The first meeting of the board was held on Monday, Apr. 17, in Chicago, at which meeting F. K. Copeland was elected chairman and secretary, and William Hoskins was elected treasurer. Mr. Junkersfeld and Mr. Hoskins were designated as the Committee on Publicity, and Captain Hunt and Dean Goss as the Committee on Finance. It was unanimously agreed that a fund of $25,000 should be raised to cover the expenses incident to the work of the board.

A. S. M. E. and S. A. E. New York Joint Meeting—The New York Section of the American Society of Mechanical Engineers and the Metropolitan Section of the Society of Automobile Engineers held a joint meeting in the auditorium of the Engineering Societies' Building, 29 West 39th St., Apr. 20. The subject of the evening was the automobile power plant with particular reference to the four-cylinder motor. Two papers were presented: "Internal Combustion Motors—the Four-Cylinder Motor of Today and Future Possibilities," by Finley Robertson Porter, president of the Finley Robertson Porter Co., Port Jefferson, L. I., N. Y., a member of both of the societies; and "Automobile Applications of Four-Cylinder Motors," by F. E. Watts, chief engineer of the Hupp Motor Car Corporation, Detroit, Mich., member of the S. A. E. The discussion brought out a good deal of interesting matter, including quite a comparison of automobile and stationary practice and the needs in the aëronautical field. Conspicuous by its absence was any defense of six-, eight- and twelve-cylinder motors, the advocates of which, if any were present, were evidently content to concede the superior fuel economy of the four-cylinder motor. The motors of more cylinders were acknowledged to perform better on direct drive so far as hill climbing and quick acceleration from slow speeds are concerned. The question of deciding upon the preferable number of cylinders under any given conditions seems to hinge upon a compromise between cost and ease of handling. The number of miles per gallon of gasoline decreases as the number of cylinders increases, but so does the amount of gear shifting.

Recent Court Decisions

Digested by A. L. H. STREET

A Steam-Roller Accident—Four-inch spikes in the rear wheels of a steam roller that was being used to repair a macadam road pierced a gas main that a heating company had laid too close to the surface of the road. Gas escaping from the pierced main spread to the firebox of the steam roller, causing an explosion in which the plaintiff, the engineer, was injured. It was held, in his suit against the heating company to recover damages, that the company cannot excuse any negligence on its part in laying the main too close to the surface because of any independent negligence of county officials in ordering the plaintiff to work along the road when they knew of the condition of the main; and that under the circumstances mentioned the jury might have found that the company was negligent and that the accident was a natural one, which might have been foreseen as a result of negligent laying of the main. (Kentucky Court of Appeals, McWilliams vs. Kentucky Heating Co., 179 "Southwestern Reporter," 24.)

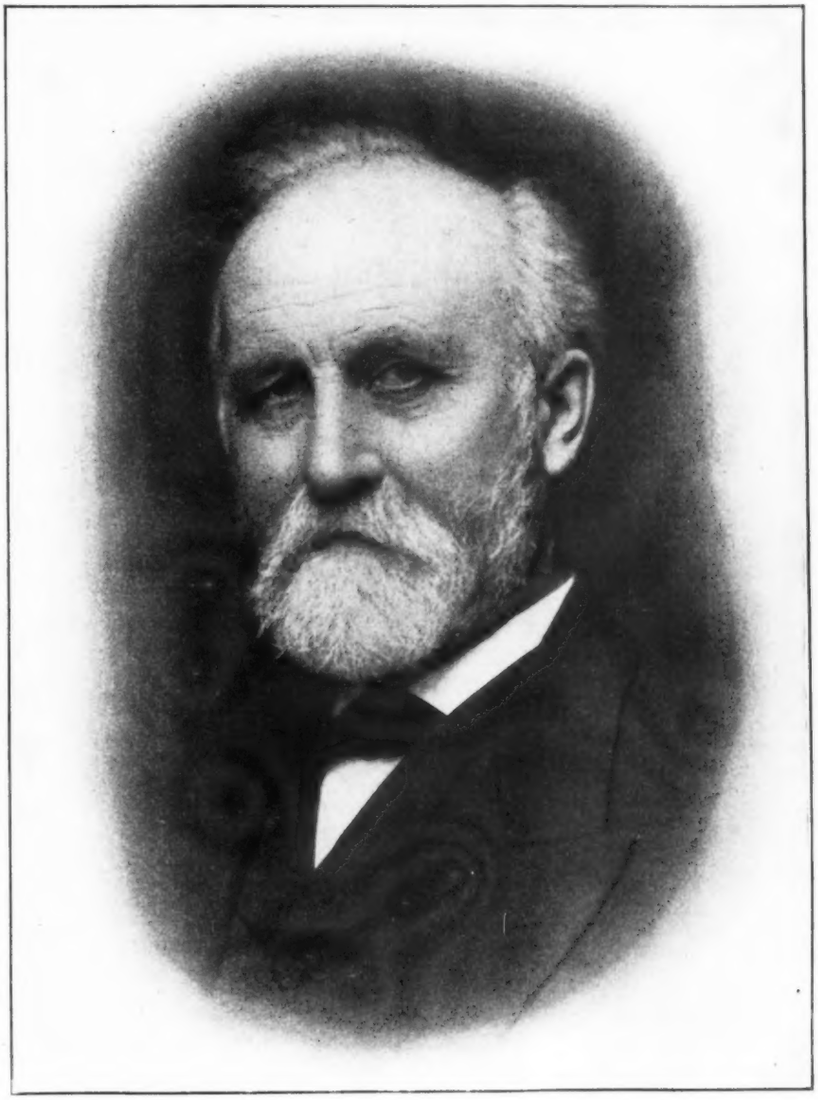
Right to Use Gas Engine in Lieu of Electricity—The State Court of Appeals, Maryland, has handed down an important and interesting decision in an action covering the use of a gas engine, upholding the right of a tenant of leased premises to install and operate such type of motive power in lieu of electric energy furnished by the owner of the building. This case, brought by the Phœnix Pad Co., of Baltimore, against a tenant in its building, set forth that the building was equipped with a power plant that produced more electric energy than required, which surplus power the tenant, it was maintained, agreed to use for operation. The contract made between the owner and tenant covered the following points: (a) The landlord to furnish the tenant with electric power at the rate of 6c. per kw.-hr., the tenant to take all of the electric power that he uses in conducting his business from the landlord, and (b) the tenant "not to do anything in or about the said premises that will affect the insurance thereon." Upon the tenant claiming that his bills for electric power were running higher than he had anticipated and arranging for the installation of a gas engine for operation, the Phœnix company sought an injunction prohibiting the installing and operating of the engine, holding that the tenant was under contract to use the electric power furnished by the building. The tenant contended that it was more economical for him to employ the gas engine and that he was under no obligations not to use it. In a lower court a decision was rendered for the tenant. In sustaining this ruling the Court of Appeals points out that one of the familiar principles applicable to suits for specific performance of a contract is that the contract must be definite and certain in all its terms and must be free from all ambiguity. In passing upon this feature of the case the court says:

> Reading the language used in the clause under consideration, we find no uncertainty or ambiguity in the terms of the contract. The clause refers to the electric current, but there is no absolute obligation assumed by the tenant to use this current. The obligation assumed by him is to take from the owner all electric current, whether for lighting or power, he might use in conducting his business. There is no express prohibition against the tenant using any other power, and we are unable to read in this contract a prohibition against the use of a gas engine by the tenant. The second clause of the contract, referring to insurance, does not establish the allegation that the installation and operation of the gas engine would affect the insurance on the building.

In its conclusions the court sets forth that under a contract of this nature the tenant was not prohibited from the use of the gas engine which he proposed to operate.

John E. Sweet Passes Away

John Edson Sweet, for many years one of the most widely known and highly esteemed men of the older generation in the steam-engineering field, died at his home in Syracuse, N. Y., on May 8, in his eighty-fourth year. He was born at Pompey, Onondaga County, N. Y., Oct. 21, 1832, a descendant of John and Mary Sweet, who came to Salem, Mass., in 1631. His education in the local schools, from the age of 7 to 15, was of an ordinary sort, but during this time, at the age of 12, his constructive resourcefulness manifested itself in the making of a violin. His mechanical disposition was sufficiently marked to bring about his apprenticeship, in 1850, to a carpenter and joiner, John Pinkerton, and with his earnings he purchased the second set of socket firmer chisels ever made. In the winter of 1850-1851 he obtained a position in the office of Elijah T. Hayden, an architect at Syracuse, and during an interval he worked for an artist named Holyoke. The architecture of that date and place was elementary, but young Sweet made the best of it and designed a barn which won a prize offered by the "Rural New Yorker." This was followed by a series of articles on architecture, which ran for a dozen years. In 1862 he went to the London exhibition, traveling on the Continent and engaging as draftsman in the international patent office of Hazeltine, Lake & Co. Later he acted as draftsman for the Patent Nut and Bolt Co., of Birmingham, while this company was building a nail machine of his invention. Returning to Syracuse in 1864, he became designer and draftsman for Sweet, Barnes & Co., which occupation he suspended long enough to attend the Paris Exposition of 1867 and show a pioneer typesetting machine which he had devised. This is still preserved at Cornell University and is a marvel of ingenuity. In 1870 he married Miss Caroline Hawthorne, who died in 1887, and two years later he married Miss Irene Clark.



JOHN EDSON SWEET

In the period from 1871 to 1873 he did chiefly bridge-building work for Howard Soule, of Syracuse, and at that time wrote articles for "Engineering," on "Mechanical Refinements." He also began work on the first straight-line engine.

Professor Sweet's ownership of that title, which has ever since remained inseparable from him, was acquired through his connection with Sibley College, Cornell University, during the period 1873-79. As professor of practical mechanics, he made a deep and lasting imprint of his personality both on the university and on his students. Under his direction they built some machines embodying features of distinctive originality, among which were the famous Cornell measuring machine, the first American-made Gramme dynamo and the second straight-line engine. The engine and other devices were exhibited at the Centennial Exposition in Philadelphia.

Professor Sweet resigned his scholastic work to return to Syracuse and engage in the commercial manufacture of his engine. To this end the Straight Line Engine Co. was formed in 1880, he becoming president and general manager and his brother Anson treasurer. They rented a building for two or three months at the start and employed six men. Here they turned out about one engine a month in sizes averaging 25 hp. In 1884 a foundry was added to the business and in 1890 a new building 130 ft. square—one of the first saw-tooth-roof shops—was occupied. Professor Sweet believed that he was the first to employ this weaving-shed type of roof for machine-shop purposes, although the priority has been disputed. There ninety men were employed in producing some fifty engines a year, averaging 80 hp. per unit. The capitalization of the company was increased and subsequently the plant and production were much further expanded. His engines have sold well, not only at home but abroad. His close relations with the Old World had therefore been reciprocal ones. His plant has not become large, but it enjoys a reputation out of proportion to its magnitude, because of the quality of the work done in it and because of Professor Sweet's strong individuality, which had permeated his mechanical output. In the formation of the American Society of Mechanical Engineers, Professor Sweet played a leading part. The idea was discussed in correspondence between him and Jackson Bailey, then editor of the "American Machinist," as a result of which a call was issued Jan. 18, 1880, over Professor Sweet's signature, and the organization meeting was held Feb. 16, in the office of the journal named. He manifested, however, some hesitancy in promoting the enterprise and an unwillingness to accept its early honors. He consented, nevertheless, to read the first paper and was its third president.

Professor Sweet never permitted his engineering abilities to grow rusty. He improved his engine from time to time and he designed other devices, such as a traversing machine and a steam separator. His forte lay in the perception and employment of those designs that were artistically and mechanically correct. Typical of his genius was one of the later among his many literary productions—"Things That Are Usually Wrong," in which he discussed bearing surfaces and other features of machine design. Over the door of his engine works he placed the inscription, "Visitors Always Welcome," and the same might have been written on his

forehead, so freely did he admit others to the confines of his brain.

The most fruitful years of Professor Sweet's life were undoubtedly those spent at Cornell. He went to the university an unknown man and left it after six years of service with a reputation that was more than national. Those were the days of small things in engineering education. The number of students was small, and the department was in a formative state, a condition which perhaps added to his success, as it undoubtedly increased the value of his work from the students' standpoint.

Few teachers have ever secured the lasting affections of their students as did Professor Sweet. Perhaps the greatest personal gratification that ever came to him was the presentation in December, 1901, of a Jurgensen watch by a number of his former students. For a number of years since, the same students, under the title of "Professor Sweet's Boys," dined with him yearly during the annual meeting of the American Society of Mechanical Engineers in New York—an occasion which was looked forward to with equal eagerness by him and by them. At the annual meeting of the Society in December, 1914, he was the recipient of the John Fritz Medal.

OBITUARY

ROBERT ALLISON

Robert Allison, inventor of the Allison cataract steam pump, which revolutionized the system of freeing underground mines from water, died at his home in Port Carbon, Penn., Feb. 3, 1916. He was born at Middletown, Durham County, England, Dec. 25, 1827, but came to this country when very young. At the age of 15 he was an asistant engineer at the Shamokin furnace and the next year was apprenticed to the firm of Haywood & Snyder, Pottsville, Penn., to learn the machinist trade. For about two years thereafter he worked as a journeyman, following which he became foreman in the shops of T. H. Wintersteen, Port Carbon, Penn., where he introduced and developed many improvements in the shops, one in particular being a tool for boring car wheels.

About 1863 Mr. Allison, in partnership with F. B. Bannan, of Pottsville, Penn., started the Franklin Iron Works, of Port Carbon. In 1878 he purchased Mr. Bannan's interest in the works and operated them alone until his retirement in 1901.

Mr. Allison was a member of several Masonic lodges, of the Historical Society of Schuylkill County, the Schuylkill Motor Club, the American Institute of Mining Engineers and the American Society of Mechanical Engineers.

GEORGE W. K. TAYLOR

George W. K. Taylor, of the McMann & Taylor Co., died at his home in Brooklyn, Mar. 7, 1916. He was born in New York City Dec. 18, 1856 and received his early education in the public schools of Brooklyn. He took a B.S. degree from Cooper Union in 1877 and his mechanical engineering degree from here in 1907. From 1874 to 1893 he was employed by the Eaton, Cole & Burnham Co. at New York and Bridgeport, Conn., in charge of designing, manufacturing and superintending the production of special valves, fittings, etc., especially adapted to high-pressure steam work for power stations.

In 1893 he formed a partnership with Mr. McMann, and this firm made a specialty of designing, manufacturing and superintending work for power plants. In 1894 he equipped the steam-power plants of the Baltimore, Md., traction system, and the Columbus, Ohio, Edison Electric Light Co. This firm was incorporated in 1910 as the McMann & Taylor Co., designing and manufacturing wrought- and cast-iron pipes, boiler tubes, fittings, valves, tools, etc., and all goods pertaining to steam, water, gas, etc.

Mr. Taylor was a member of the American Society of Mechanical Engineers, the Machinery Club of New York, the Society of Old Brooklynites, the Chamber of Commerce, the Merchants' Association, the Old Union League Club of Brooklyn, director of Greenwich Bank, trustee of St. John's Methodist Episcopal Church of Brooklyn, and was a 32nd degree Mason.

ENOS M. BARTON

Enos M. Barton, founder of the Western Electric Co., died on May 3, at Biloxi, Miss. Hinsdale has been his home for many years, and the funeral was held in Chicago on May 6. Mr. Barton was born at Lorraine, N. Y., Dec. 12, 1842. At the age of 12 he procured work as a telegraph messenger boy at Watertown. The operator had been a school teacher, and the messenger boy became his pupil, studying Latin, arithmetic and algebra. Besides, he learned the code and became an operator. His studies were continued at Rochester University while working as a night operator for the New York Central Railroad.

In 1869 he was chief operator at Rochester, but because of a cut in salary, quit his job and became identified as a member of the firm of Shawk & Barton, telegraph instruments, of Cleveland. This firm was the nucleus of the Western Electric Co. Later the partnership became Gray & Barton, and in 1879 the plant was removed to Chicago to make all of the equipment for the Western Union. The Western Electric Manufacturing Co., was then organized, with Gen. Anson Steger as president and Mr. Barton as secretary. When peace was made with the Bell companies, Mr. Barton became vice-president of the new Western Electric, and in 1887, president. In the latter capacity he continued until his retirement in 1908. In addition to his duties as the head of the Western Electric Co., Mr. Barton found time for other business interests and for various social and philanthropic activities. He was twice married and is survived by his widow and seven children.

PERSONALS

William H. Van Dervoort, president and manager of the Root & Van Dervoort Engineering Co. and the Moline Automobile Co., has just been elected president of the National Metal Trades Association.

Alexander C. Brown, vice-president of the Brown Hoisting Machinery Co., Cleveland, Ohio, has been appointed general manager, succeeding Richard B. Sheridan, who has resigned to accept another position.

Howard B. Clark has resigned as Eastern representative of the McNaull Boiler Manufacturing Co., of Toledo, Ohio, to become engineer of operation and maintenance of the National Carbon Co., Cleveland, Ohio.

Charles A. R. Haynes has resigned as assistant engineer with the New York Steam Co., New York, to become supervisor of scheduling of the plant department of the Winchester Repeating Arms Co., New Haven, Conn.

Theodore B. J. Merkt, until recently with the Pyrene Manufacturing Co., New York, as experimental engineer, has become associated with Westinghouse Church Kerr & Co., New York, in the capacity of assistant engineer.

William L. Wotherspoon has become consulting mechanical and electrical engineer to the International Nickel Co., New York. He was until recently with the Canadian Mining and Exploration Co., New York, in the same capacity.

Clement F. Street, vice-president of the Locomotive Stoker Co., has been awarded the John Scott Legacy Medal and Premium by the City of Philadelphia, acting on the recommendation of the Franklin Institute for the Street locomotive stoker.

A. L. G. Fritz has accepted the position of superintendent of construction with Ford, Bacon & Davis, at Kingsport, Tenn. He was until recently superintendent of construction of the new Burlington power station of the Public Service Electric Co., Burlington, N. J.

James McIlvrid, who for years was manager of the Cockburn Co., and its successor, the Standard Gas Power Corp., has retired from the latter concern and opened a machine shop in Jersey City under the name of the Mutual Iron Works, where he is building a complete line of special machinery.

Frederick Sargent, of the firm of Sargent & Lundy, Chicago, Ill., sailed from New Orleans, La., for Chile, on Apr. 5. Mr. Sargent is making this trip in behalf of the Chile Exploration Co., a firm that is identified with the Guggenheim copper interests. He expects to return to Chicago in about two months.

Charles L. Edgar, president of the Edison Electric Illuminating Co., Boston, and J. B. McCall, president of the Philadelphia Electric Co., have been appointed to represent the central-station industry on the campaign executive committee for the "America's Electrical Week" celebration next December.

Dr. W. F. M. Goss, dean of the College of Engineering of the University of Illinois, upon the nomination of the American Society of Mechanical Engineers, has been appointed by Hon. Josephus Daniels, Secretary of the Navy, as a member of the Board of Directors of the Organization for Industrial Preparedness for the State of Illinois, and as associate member of the Naval Consulting Board.

Henry Souther, vice-president of the Ferro Machine and Foundry Co., Cleveland, Ohio, and past-president of the Society of Automobile Engineers, has severed his connection